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SURGERY

A Monthly Journal Devoted to the Art and Science of Surgery

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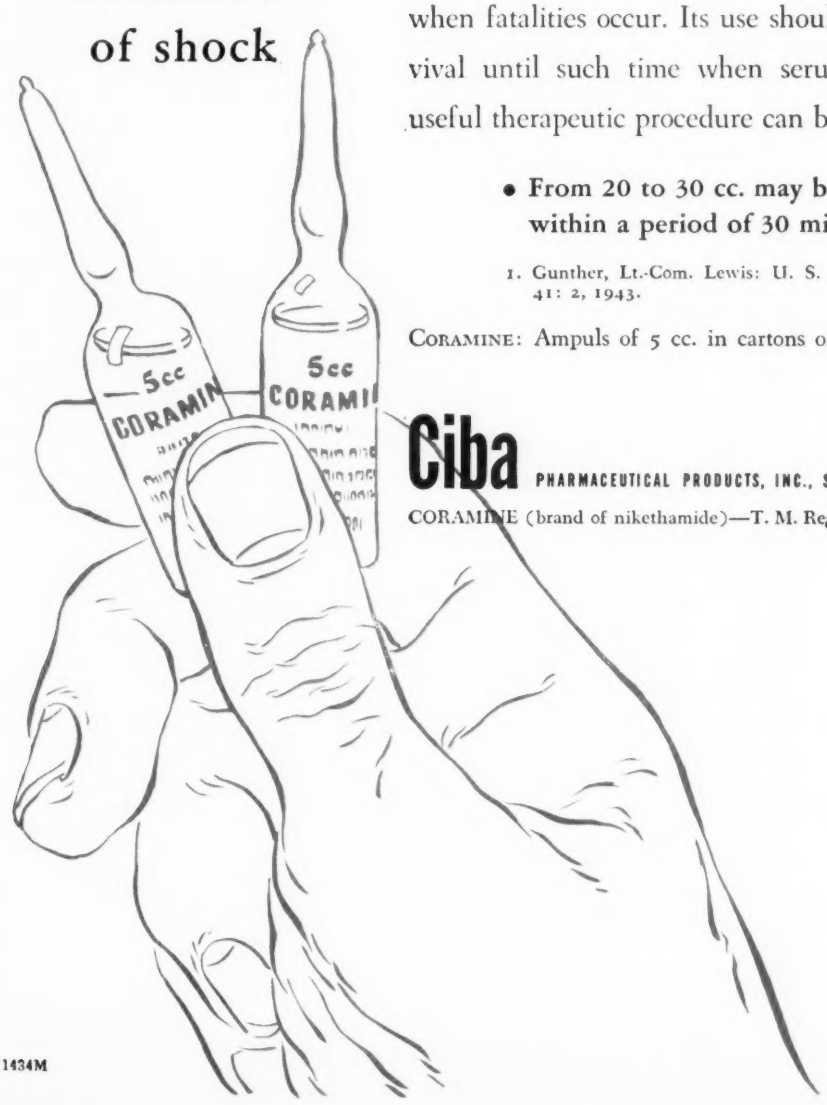

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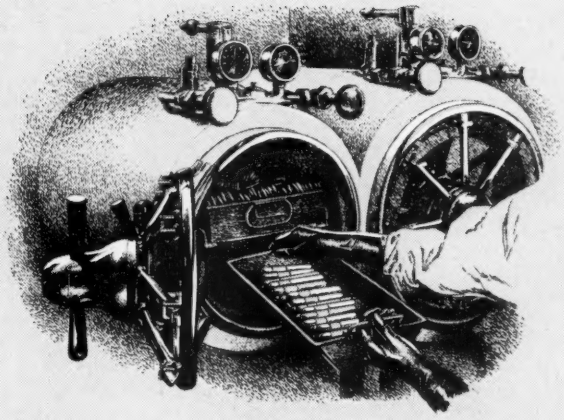

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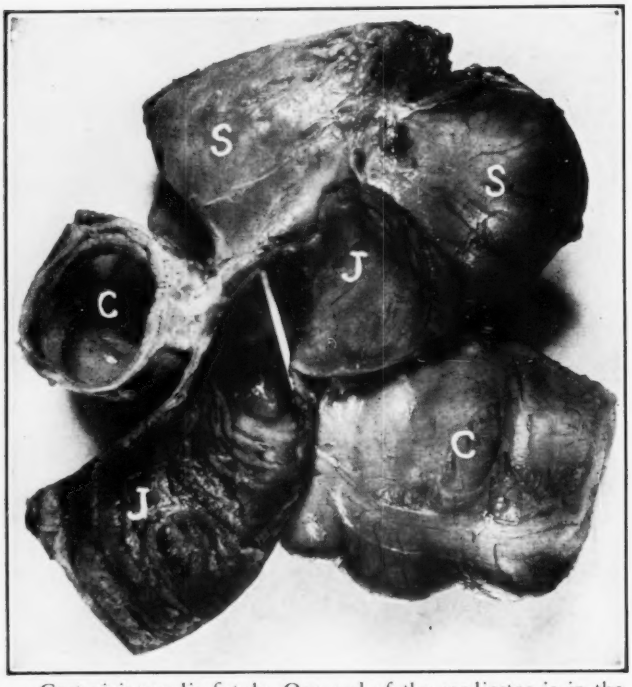

Gastrojejunocolic fistula. One end of the applicator is in the stomach (S) while the other end is in the colon (C). The jejunum (J) has been opened.

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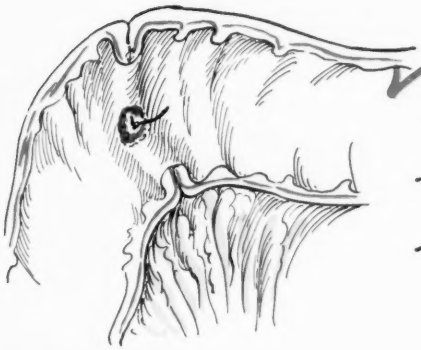

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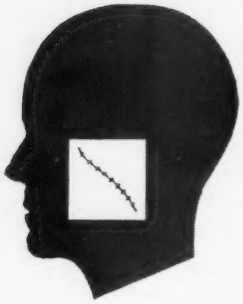

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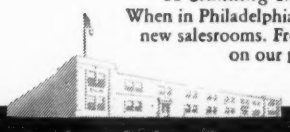

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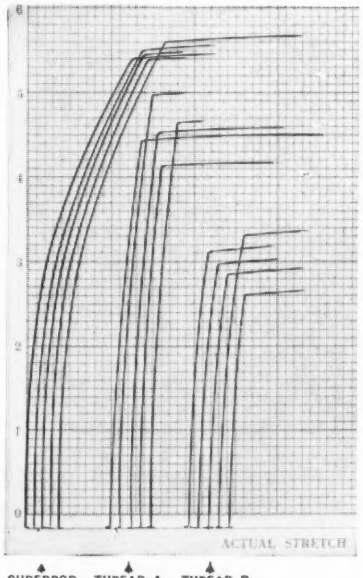

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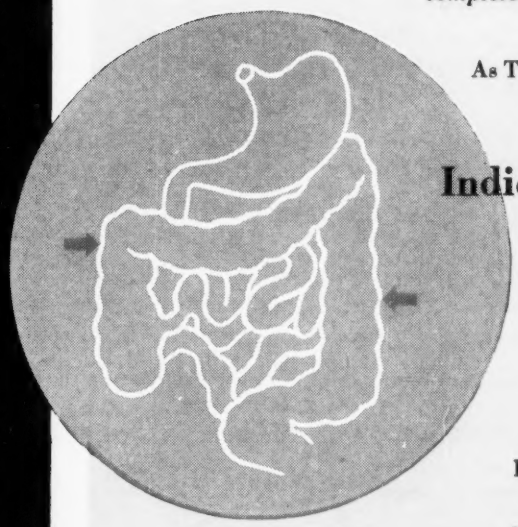

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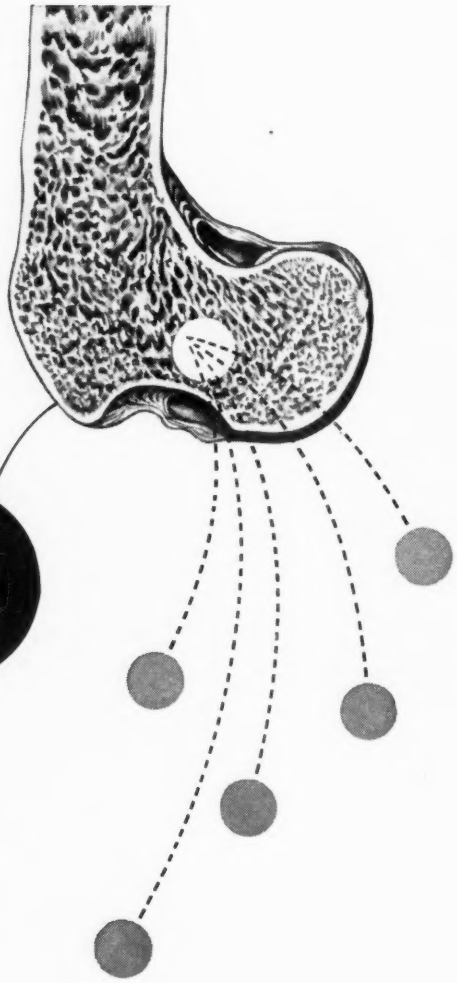

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DETERMINING FACTORS IN THE SAFETY AND SUCCESS OF PRESENT-DAY RADICAL SURGERY

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THE history of surgery may be divided into three periods, decreasing in length, but increasing in significance. In the first period, beginning with recorded history until 1846, little advance was made. Whatever surgery was done had to be done with the greatest speed and trauma, and almost entirely upon the extremities that could be controlled, regardless of the struggles of the agonized victim. In the Trustees Room of the London Hospital hangs a large bell. Before the advent of anesthesia, it had been used in the main hall of the hospital to summon the orderlies to control the patient who was to be operated upon.

From 1846 to about 1910 came the second period. The discovery of anesthesia and the development of antisepsis and asepsis made deliberate surgery possible and the attack upon organs and body cavities began. New approaches and new methods of excision and repair were multiplied and improved. Attention was concentrated on techniques of operations in many fields and specialities. Amazing advances were made along these lines but the condition of the patient limited the operative time in certain areas and kept the surgeon out of others altogether. A few men like Kocher and Halsted appreciated the importance of maximum hemostasis and minimum tissue trauma, but by and large, attention to technical procedure rather than the study of the patients' reactions to disease and trauma was characteristic of this pioneer period.

Beginning in the early years of this century, during the past forty years, with increasing tempo, the attention of the surgeon has centered on the study of the disturbed physiology of the patient and the effects of disease and trauma on the individual. Because an understanding of this disturbed physiology demands a knowledge of chemistry and physics, more of our young surgeons have spent part of their training in the basic sciences in preparation for their surgery. The advances that have been made in thoracic and abdominal surgery, in the

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surgery of the ductless glands, in pre- and postoperative care with transfusion and blood substitutes, and nutritional studies are the result of the philosophy and point of views of this last period—which by the way is not ended.

The philosophy of modern surgery as a special branch of therapy in the science of medicine is based upon what we call surgical principles—principles involving anatomy, physiology, pathology, and medicine. Some of these principles are established and are more immutable than the laws of the Medes and Persians. Others, though considered so by many surgeons, are not. They change with new concepts in the sciences mentioned and then cease to be established. Note the change in present-day early mobilization after operation. Ten years ago getting a patient out of bed the day after a partial gastrectomy, a cholecystectomy, or a hernia repair would have been considered as an infraction of an established surgical principle. The emergencies of the war, as well as greater care and thought in wound repair with fine, nonabsorbable suture technique, have demonstrated unquestioned advantages to the patient, of so-called early ambulation.

During the past decade, such striking advances have been made in the extent and scope of radical surgery, especially in neoplastic disease, that it is pertinent to analyze the factors that are responsible for the feasibility and safety of operations that had not previously been thought of, or had been considered too hazardous. Consideration of this question inevitably calls attention to the importance of improving the factors known to be responsible for making this present-day surgery possible, as well as eliminating certain conditions, known and unknown, that still compromise the safety of radical procedures.

My discussion of this subject with leading surgeons in this and other countries interested me because of the varying emphasis given by them to these determining factors. To get more considered and definite opinions, I sent a short questionnaire (with apologies) to a number of leading surgeons in this country, who, I knew, were interested in and were doing radical procedures. In this questionnaire I listed eight factors in more or less alphabetical order, at the same time leaving out the one I consider most important, and asked for criticism, comments, and additions, and requested that they list these in numerical order of importance. The responses were as a rule cordial, thoughtful, and constructive. In naming these factors I was aware that in some of them there was considerable overlapping, but I was interested to get the analysis of other surgeons. After giving the combined opinion of the surgeons in the order of importance of these factors, I shall discuss these and others not included in the questionnaire.

The summary of their opinions, in order of importance, is as follows: (1) blood transfusion; (2) pre- and postoperative care (an overlapping factor); (3) nutritional studies, anesthesia; (4) protein, fluid, and electrolyte studies; (5) chemotherapy; (6) new physiologic concepts; (7) new techniques.

This summary obviously is open to the criticism of any collected data of too small a series, and it is of value only in the emphasis given to the first two factors. Opinion from there on differs widely in interpretation and emphasis. These factors will be discussed, but not necessarily in the order previously given.

TRANSFUSION

There is little question that blood transfusion as now used, before, during, and after operation, makes possible the long, complicated procedures, especially in patients with cancer, and helps most definitely in the immediate and later recovery. Well-organized blood banks, as now established in our best hospitals, are essential in insuring accurate blood grouping, determination of the RH factor, and maintaining sterile and pyrogen-free apparatus. It must be understood that a blood bank should be in charge of one thoroughly trained and experienced in the entire field of transfusion technique, and in the prevention and treatment of transfusion reactions. One other factor in insuring the maximum benefit of transfusion therapy is blood cell and plasma volume estimation to determine the need for blood, the amount to be used, and the avoidance of giving too much, especially in a patient with cardiovascular pathology. The role of increased oxygen supply to the anemic patient through increased red cell circulation is obvious. There is undoubtedly an added safety factor in preventing damage to parenchymatous organs, such as the liver and brain, by maintaining an adequate oxygen supply through transfusion.

Closely allied to blood transfusion therapy are other factors—protein, fluid, electrolyte, and nutritional requirements. In the majority of patients with radical resection and physiologic revision, there has been a prolonged disturbance in normal blood chemistry, which must be determined and corrected before radical surgery is attempted. This implies clear understanding and close cooperation between the surgeon, the anesthetist, and the biochemist and physiologist working on these problems. The anemia, the depleted nutrition and disturbed serum protein and electrolyte ratios must be studied, and often cannot be immediately corrected, but should be, before radical surgery is attempted. Sufficient time must be allowed for bringing the patient to a more normal state, and where obstructive lesions are present, a two- or more stage procedure is often necessary. Low serum protein and vitamin C levels may nullify the most skillful surgery by the failure of wound healing. On the other hand, overloading the circulation with fluids and glucose-saline, in the presence of cardiorenal disease, or low protein levels, may induce worse edema and more pulmonary complications. This is often seen in the too enthusiastic therapy of interns and residents inexperienced in surgery and anesthesia, to whom the busy surgeon has delegated all such therapy. One sees such overhydration in patients with radical pancreas and liver surgery. Here hematocrit cell and plasma volume determinations, and electrolyte studies, are most important in estimating the amount of blood, salt, and fluid therapy, and often one of these determinations alone may be very misleading.

One of the most recent advances in transfusion therapy, now carried out most spectacularly at the Columbia-Presbyterian Surgical Service, is the use of arterial transfusion, under varying pressures, in patients with hemorrhage and in severe or irreversible shock. Under such shock, the left heart is unable to get enough blood to deliver to the aorta. One of the first and most serious effects of this is the anoxemia of the heart muscle, due to decreased flow of blood to

the coronary arteries. Arterial transfusion, under controlled pressure, forces blood to the aorta, and the hepatic and cerebral vessels, where oxygenated blood is most needed. Coronary flow is increased and cardiac tone restored. Future reports on this type of transfusion will be most interesting and constructive.

ANESTHESIA

Newer anesthetic agents and improved methods of administering them by trained physician anesthetists must rank high in making radical surgery feasible and safe. To make all patients fit one type or agent of anesthesia is as stupid as making the patient fit an operation instead of adapting the procedure to the individual patient. This fitting the anesthetic to the patient for the best immediate and late results demands close cooperation between the surgeon and the anesthetist. Neither should assume the omniscient attitude, and pay no attention to the other's opinion. The newer combinations of sodium pentathol-curare, cyclopropane-curare, Novocain continuous spinal, cyclopropane-oxygen-ether, and intratracheal anesthesia with the foregoing combinations, as well as suction bronchoscopy, have in the past ten years broadened the field of anesthesia, facilitated the work of the surgeon, and increased the safety to the patient.

Inasmuch as the surgeon is legally responsible for the patient on whom he operates, he should have the final decision as to the anesthesia he is to work with, but he should have all the data pertinent to the patient's condition available for consultation with the anesthetist, and should give the anesthetist every consideration in deciding on the type and mode of anesthesia in a critically ill patient. There is no question that a physician anesthetist, trained in medicine and in physiology and in the newer forms of anesthesia, is the best qualified to advise and supervise the administration of the anesthetic selected for the individual patient, as well as in the pre- and postoperative care of the patient. Such a trained anesthetist, if he is wise, will not take a dictatorial attitude toward the surgical team. If he does that, he will soon cause no end of trouble and will not advance the cause of the physician anesthetist. Tact would seem to rank very near to skill in the anesthetist. Teamwork between the anesthesia team and the surgical staff in the preoperative, operative, and postoperative care of the patient, is one of the most precious possessions of a surgical service.

In hospitals where it has been tried with adequate emergency-measure equipment, and with specially trained nurses and the cooperation of the anesthesia and surgical staffs, a recovery ward has given great satisfaction. This is especially true in thoracic surgery, and in patients having thoracoabdominal resections of the esophagus and stomach—in fact, in all types of radical surgery. Ochsner* considers the recovery ward one of his greatest safety factors.

CHEMOTHERAPY

The popular but unintelligent faith in the new "magic drugs" has unfortunately been shared by many physicians and surgeons in their thoughtless use of the sulfonamides, penicillin, and streptomycin, to mention the three

*Alton Ochsner. Personal communication.

prominent varieties. To determine their true worth and real effectiveness, it is necessary to understand the bacteriologic and pathologic conditions in which one or more of them is valuable and the indications for their use as well as the results to be expected. There is no magic in these chemotherapeutic and antibiotic agents and any surgeon or physician using them on that assumption is exhibiting stupid ignorance. If they are used in lesions where surgery is indicated, not done, or poorly done, leaving dead tissue or undrained, established infection with necrotic tissue and pus, no benefit other than preventing systemic invasion of the blood stream and normal tissues can be expected.

The systemic and local use differs in the different drugs. These agents which are not so much bactericidal as inhibitors of bacterial growth and proliferation, assist the normal antibodies and reticuloendothelial cells to phagocyte the bacteria whose capacity for multiplying has been inhibited. Their effectiveness depends upon the free contact of the drug containing blood serum and plasma with the tissue cells and intercellular tissue spaces, and the bacteria in them. If this contact is prevented by walls or barriers of necrotic tissue or abscess membrane, or by necrotic tissue, slough, or involucrum, or any foreign body harboring bacteria, the bacteria will continue to proliferate, drugs notwithstanding. In this respect, many surgical infections differ from medical infections. It is the surgeon's function to remove dead avascular tissue, provide free drainage when indicated, and re-establish this essential vascular contact in dealing with surgical infections. The rate and effectiveness of the response of the infected tissue to these agents depends first on the vascular contact of the area, second, on the removal of necrotic tissue or foreign body, and third, on the susceptibility of the infecting organism to the agents used. Probably the most important aspect in the systemic use of these drugs in susceptible organisms is the prevention of spreading infection to surrounding uninfected tissue, and proliferation of the organism in the blood stream and embolic proliferation; in other words, the prevention of bacteriemia, septicemia, and pyemia.

Clinical use of these agents has demonstrated the fact that infection of serous cavities like the pleura, peritoneum, and synovial cavities responds in the early stages without surgical interference because of the copious discharge of drug-bearing fluid and exudates into the cavities. Similarly in early osteomyelitis, while there is still free flow of blood in the Haversian canals, and before necrosis of bone develops, the subsidence of the infection without surgery is often prompt and dramatic if the organism is susceptible to the drug used.

In the radical procedures now being done, the administration of penicillin in general and of streptomycin and such special sulfonamides as sulfasuxidine in gastrointestinal resections is effective in preventing contaminated tissues from developing established infections. Again the surgeon must not add to the amount of necrotic tissue by the use of heavy hemostats and ligation of unnecessary tissue in hemostasis. He should use fine hemostats and ligature and suture material that is not more than twice as strong in tensile strength as the included tissues. He should insure the maximum blood supply to the repaired tissues if he is to get the benefit of the systemic use of these agents.

There is no doubt that systemic chemotherapy has decreased the incidence of local infections and has resulted in a great reduction of pulmonary and uri-

nary postoperative complications following major surgery. But the local application of these drugs is of doubtful value, and the indiscriminate haphazard dumping of large amounts into the peritoneum or soft parts is unwarranted and unintelligent. However, there is no question that, given systemically, the sulfonamide group and penicillin and streptomycin have very definitely prevented blood stream infection, diffuse spread of infection in normal tissue, and postoperative complications. Used intelligently and for individual operations, these antibiotics have strikingly reduced the operative hazard in many fields of surgery. This is especially true in resections of the lung, in esophagogastric resections, and in radical colon and rectal surgery. But again it must be emphasized that these drugs will not prevent residual infection in the presence of bacteria-laden foreign body or necrotic tissue, the result of mass ligature or damaged blood supply.

NEW TECHNIQUES AND NEW PHYSIOLOGIC CONCEPTS

One of the interesting and positive trends in the past twenty-five years of American surgery is the emphasis placed upon the training in physiology in long-term preparation of the young surgeon. This is in contrast to the emphasis previously given to pathology and, prior to that, to anatomy, as the sine qua non of the surgeon's training. The fact is that a knowledge of basic anatomy and pathology is just as necessary for a surgeon today as it ever was, but research experience in basic physiology and in experimental physiology is essential if a surgeon aspires to original contribution.

Perhaps no field of surgery so well illustrates this dictum as that of thoracic surgery. The great majority of the advances in this area have been made by physiologically minded surgeons. Similarly in vascular surgery, and most recently in the blood-shunting procedures, intrathoracic and intra-abdominal, the advances have been made as a result of experimental surgery made possible by the physiologic advances in anesthesia, blood transfusion, and circulation and respiratory ratio studies.

Physiologic discoveries such as insulin, vitamin K, heparin, and many others have been applied to various fields making individual procedures safe, which formerly were prohibitive. Furthermore, the surgeon has contributed original observations which have made possible radical procedures, previous physiologic concepts notwithstanding. Thus in 1918, Dragstedt demonstrated that an animal could survive a total duodenectomy. The duodenum had been partially resected successfully in a very few patients but it was the use of vitamin K, blood and electrolyte therapy that made the one-stage radical pancreaticoduodenectomy and total pancreatectomy a feasible and warranted procedure.

The Russian physiologist, Eck, first demonstrated the feasibility of the portacaval shunt as early as 1878. A few abortive attempts to carry out the procedure in human beings, but with prohibitive results, were made in the first twelve years of this century. For many years George Whipple continued to do this operation on dogs for physiologic studies in protein metabolism and hematopoiesis. Some of his animals survived for seven years. Yet it was not until there was a better understanding of liver physiology in relation to the portal

circulation, and certain advances in technique, that successful attempts to apply the shunting portacaval procedures in human beings were warranted.

The many advances in thoracic surgery made possible by endotracheal anesthesia led surgeons to attack more radically the cancers and strictures of the esophagus and upper third of the stomach. These successful resections without the distressing esophagostomies and gastrostomies have broadened the entire field of thoracoabdominal approach. In many of these procedures both vagi were divided without serious sequelae. This undoubtedly warranted renewed efforts to treat ulcer pain and decrease acid secretion by double vagotomy, now one of the most interesting surgical attacks in ulcer therapy.

Another new approach to upper abdominal pain therapy is thoracoabdominal sympathectomy to divide the efferent sensory nerve paths from the pancreas and the biliary tree. Certainly this is a safer procedure for intractable pain in pancreatic lithiasis than partial or total resection of the pancreas. Sympathetic block with Novocain is being used in acute pancreatitis. But both these procedures need further follow-up studies to make sure that the removal of pain does not remove the warning signal of the development of acute or chronic inflammatory lesions.

One of the most interesting advances in physiologic study of the blood and in diagnosis of cardiac anomalies has been accomplished in the last decade by intravascular catheterization. Ureteral-like catheters have now been passed into all chambers of the heart, and blood samples have been drawn from them, as well as from the coronary veins, the hepatic veins, the renal veins, and other branches of the general and pulmonary venous systems. As yet, the portal vein has not been tapped, but I am confident that Blakemore will soon report such studies following an Eck fistula or a splenorenal shunt.

The possibilities in the study of liver pathology by analysis of blood samples from the hepatic and portal veins are intriguing, as they have been in the study of congenital heart lesions reported by Bing* in Blalock's operations for pulmonary stenosis and other cardiac anomalies.

The use of radioactive and stable isotopes—so-called "tagged elements"—is coming to have a wide application in clinical research, both medical and surgical. With the development of chain-reacting piles under the control of the Atomic Energy Commission and the availability through the Commission of isotopes of many elements, with astonishingly different half lives, the field of research has widened immeasurably. As examples, this involves the study of cell membrane permeability and transfer, the tracing of metabolic pathways by tagging complex compounds, and fluid space measurement. These studies are of the greatest significance in the study of normal and abnormal physiology, and require the teamwork of the physicist, physiologist, and biologist. They are not without hazard, however, both to subject and experimenter, because of the effects of radiated atoms, and should not be attempted by the uninitiated. But the application of the measurement of "total body constituents" to the determining factors of fluid, electrolyte, and protein balance and nutrition in the preoperative and

*Bing, Richard J.: Mod. Concepts Cardiovas. Dis. **17**: 3, 1948.

postoperative care of the patient are becoming increasingly important to the surgeon.

These are a few examples of modern surgical procedures, some of which have been less radical, others more radical, because of new physiologic concepts, or older concepts made applicable by the newer adjuvants to radical surgery.

THE CARE OF THE PATIENT

Care of the patient includes the preoperative, the operative, and the postoperative care, as well as the essential follow-up studies. These phases of care involve very closely the factors already mentioned. But the proper application of these factors depends upon one not mentioned in the questionnaire. It was purposely not included, to find out how many other surgeons rated it as high as I do. Several of them called attention to its omission and placed it at the top.

This factor is the careful selection and training of the resident staff. For without competent residents, the other significant factors in insuring the safety of the present-day radical surgery will not be understood and intelligently implemented. Several of the surgeons to whom the questionnaire was sent rated pre- and postoperative care at the top, including intra-operative care, so that it ranked second in the summary of replies. These opinions undoubtedly implied an adequately trained staff.

Surgery is essentially a theraupeutic branch of medical science. It carries with it hazards as well as benefits, both so great that they cannot be understood nor appreciated without a period of training in the basic sciences and preclinical subjects, as well as in the broad discipline of symptomatology and diagnosis of disease, and the indications for therapy. But the carrying out of surgical therapy is an art as well as a science and requires a long apprenticeship of several years under careful tutelage. The actual operative skill cannot be gained by observation, any more than skill in playing the violin can be had by hearing and seeing a virtuoso performing on that instrument.

Increasing responsibility in the various phases of the patient's care should be given as the resident shows his experience and ability. Adequate training in general surgery is essential before beginning training in the surgery of a specialty, and with such previous experience in general surgery a shorter period of training in the specialty than is now required will make a better surgeon in the specialty. For at least some of the surgical staff there should be opportunities for continuing investigative studies. A resident who has been exposed to the discipline of research will almost always make a more intelligent and capable surgeon than one who has no more training than a surgical technician.

A recent incident that occurred on the surgical service of one of our University Clinics illustrates the versatility of a senior resident trained in the study of the patient's condition as well as in operative technique. One of the senior surgeons had performed a very difficult operation for the removal of a large retrosternal goiter. He was called in the afternoon to an out-of-town consultation and could not be reached. The thyroid patient developed an increasing dyspnea. The resident opened the wound, evacuated blood clots, and relieved the dyspnea. However, bleeding continued and the patient went into profound

shock. He was pulseless; blood pressure was zero. An immediate intra-arterial transfusion was begun; the patient was taken to the operating room. The resident split the sternum and ligated the actively bleeding vessel. Transfusion by vein was then continued until the blood pressure and pulse rate were normal. The next morning the patient was sitting up in bed reading the newspaper and continued to make a satisfactory convalescence.

A surgical service will have teamwork only if the attending staff are really competent, interested in teaching the resident staff, and genuinely interested in the best welfare of the patients. The head of the service, especially, should embody these qualities, for he should set the pace, apportion the work, and, most of all, watch the development of the residents. Especially at the operating table is the teamwork of the staff best shown. I have always thought of the operating team as a quartet or sometimes a quintet or sextet. Their opus has just as many changes in tempo and nuance as any musical quartet. The operator should dominate the team as does the first violinist in the quartet, and should see to it that all stages of the procedure are not in one tempo—presto or adagio—but modulated to accommodate the several periods of the operation. A quiet but assured control of the procedure is evident in some surgeons, as is the violent temper and excessive showmanship in others. Too often the ability of a surgeon is compromised by his temper exposed in the operating room, and he becomes his own worst handicap.

Certainly in no other field of medicine is the blessing of *aequanimitas* more evident in the man and his influence on his associates than it is in the surgeon. His prayer should be, "Give me skill with humility, and prevent me from becoming a prima donna."

ANGIOCARDIOGRAPHY IN THE DIFFERENTIAL DIAGNOSIS OF PULMONARY NEOPLASMS

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ROBB and Steinberg,[1] in 1938, presented fundamental observations concerning the role of angiocardiography in the interpretation of a variety of intrathoracic lesions. For example, they noted changes in the branches of the pulmonary artery in tuberculosis and bronchiectasis, obstruction of the innominate vein by substernal goiter, and displacement of the great venous channels by mediastinal tumors or widespread fibrosing pulmonary lesions. In the present investigation, the Robb and Steinberg procedure was used, with the addition of a multiple roentgen exposure technique, as described previously.[2] Our study, which is still in progress, is being carried out in order to ascertain the effects of various pulmonary neoplasms upon the pattern of the pulmonary artery and its branches. The interpretation of the alterations has been materially aided by comparison with the films of operative specimens in which the pulmonary artery was injected with a radiopaque material. The experimental and clinical studies of Wood, Crever, and Miller,[3] as well as those of Mathes, Holman, and Reichert,[4] who injected the pulmonary and bronchial arteries in numerous postmortem specimens, were available for comparison.

A thorough study of many normal lung specimens by Appleton[5] revealed that the following blood vessel arrangement is present in the majority of instances. The upper division of the right pulmonary artery commonly provides arteries for the pectoral, apical, and posterior lung segments, but it is not the sole supply of the upper lobe. One, two, or three ascending arteries also enter the lower part of this lobe from the lower pulmonary division. The artery to the dorsal segment of the lower lobe usually arises very close to the posterior ascending artery and sometimes shares a common stem. The lower division of the right pulmonary artery is the sole supply of the middle lobe (generally by 2 branches), and the lower lobe. The left pulmonary artery while arching over the left upper lobe bronchus provides arteries for the apical and posterior segments. The artery for the pectoral area occasionally arises anteriorly before the arch; more often, it arises afterward, and it is then below the origin of the artery of the dorsal segment of the lower lobe. The lingular artery usually arises after the main artery has curved over the bronchus. The larger collecting veins lie on the periphery of the various lung segments. These veins drain adjacent areas and form an anastomosing system throughout the lobes, finally emptying into two large pulmonary veins on each side.

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The value of angiocardiography in differentiating vascular and nonvascular intrathoracic lesions has been previously reviewed.[6] The present report concerns the application of this procedure in the differential diagnosis of the various types of pulmonary neoplasm. Angiographic studies in cases of malignant tumors of main bronchi, which are usually infiltrative in nature, revealed that the large pulmonary vessels in the area of the neoplasm are, in the majority of cases, partially or completely occluded (Fig. 1). Pathologic study of the specimens removed at operation confirmed this finding and indicated that the vascular pattern of the lung can be of considerable value in establishing the diagnosis. For example in one patient, the clinical history was suggestive of a bronchiogenic lesion. The customary roentgenograms revealed no tumor mass. Pulmonary angiography demonstrated upward displacement of the main stem artery of the right upper lobe, the branch arteries being somewhat thinner and more spread apart than usual. The adjacent segment of the superior vena cava was distorted (Fig. 2). On the basis of previous experience, a main bronchus-infiltrating neoplasm was suggested and this was confirmed at operation.

In the malignant tumors of small or branch bronchi, similar findings are obtained. The vessels in the area of the tumor are irregularly distorted or occluded, but since the lesion is situated toward the periphery, only relatively small pulmonary vessels are involved (Fig. 3). Thus, even though the effects seen in the angiocardiograms are not as dramatic as with occlusion of a major pulmonary vessel, they are of substantial aid in establishing a diagnosis. These vascular changes are to be contrasted with the effects produced by benign, slowly expanding lesions (Fig. 4). In these cases, the vessels are displaced and surround the tumor, but are intact. A small well-circumscribed malignant lesion, seen as a sharply delimited circular shadow in the roentgenogram, may present a vascular pattern identical with that of a benign intrapulmonary lesion. The specific changes which have been enumerated seem to be characteristic of irregular infiltration. However, vascular occlusion may be caused by pulmonary embolization and of itself is not pathognomonic of tumor.

By way of contrast, reference should be made to one case in which the clinical history and roentgen findings were those of a malignant pulmonary neoplasm. Angiocardiography did not reveal any of the anticipated abnormalities of vascular pattern. At operation, there was encountered a chronic pulmonary abscess. No evidence of neoplasm was found.

In mediastinal or other extrapulmonary tumors of even substantial size, angiocardiography usually reveals an essentially normal vascular arrangement.[6] The only abnormality which is occasionally encountered is displacement of an adjacent segment of lung with its vascular components.

There was one case of thyroid carcinoma with multiple metastatic pulmonary nodules in which an angiogram was made. The metastases caused no detectable alteration from the normal vascular pattern, presumably because an alteration in the arrangement of finer vascular branches was not produced.

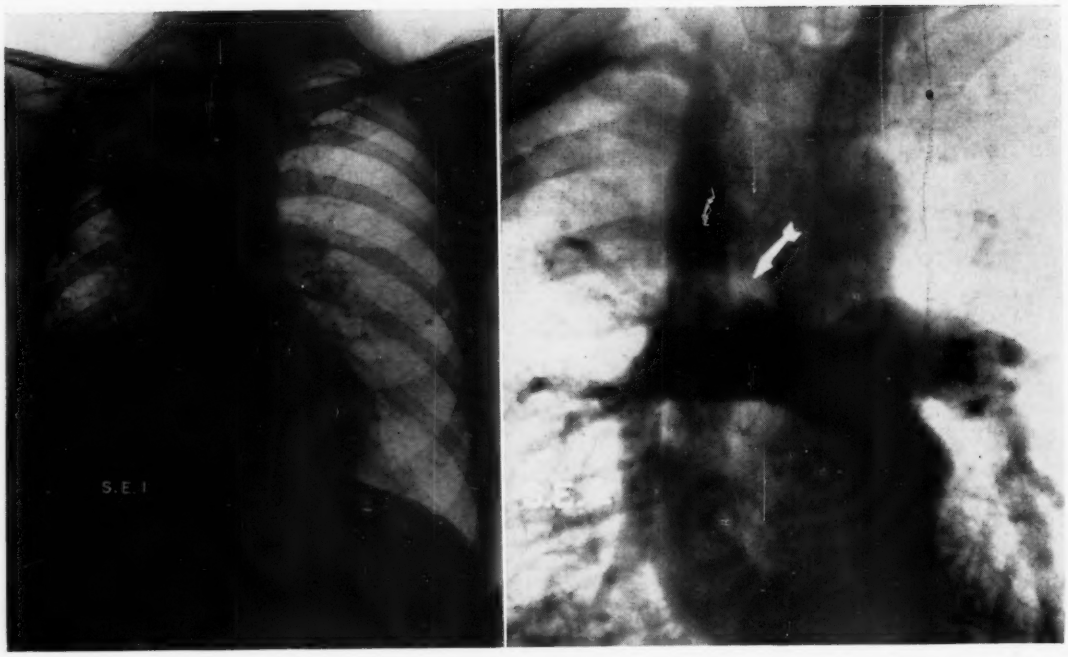

Fig 1.—Carcinoma of right upper lobe main bronchus; major pulmonary artery to this lobe abruptly occluded (arrow) by neoplasm.

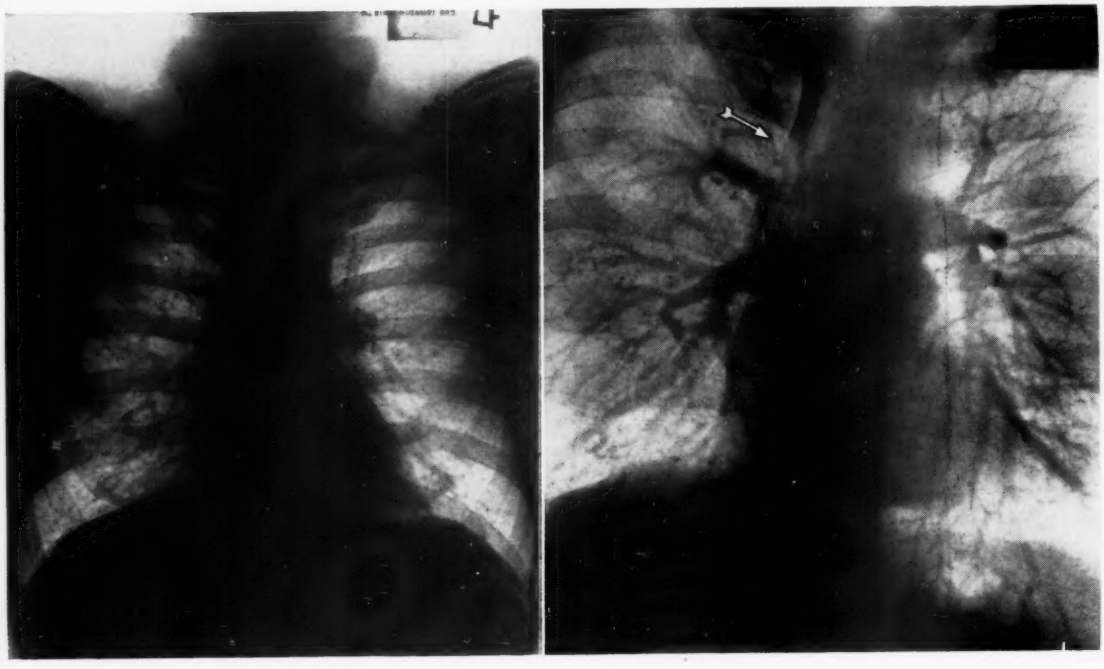

Fig. 2.—No pulmonary tumor visible on routine chest film; pulmonary angiogram reveals upward displacement of major artery to right upper lobe and pressure on adjacent superior vena cava.

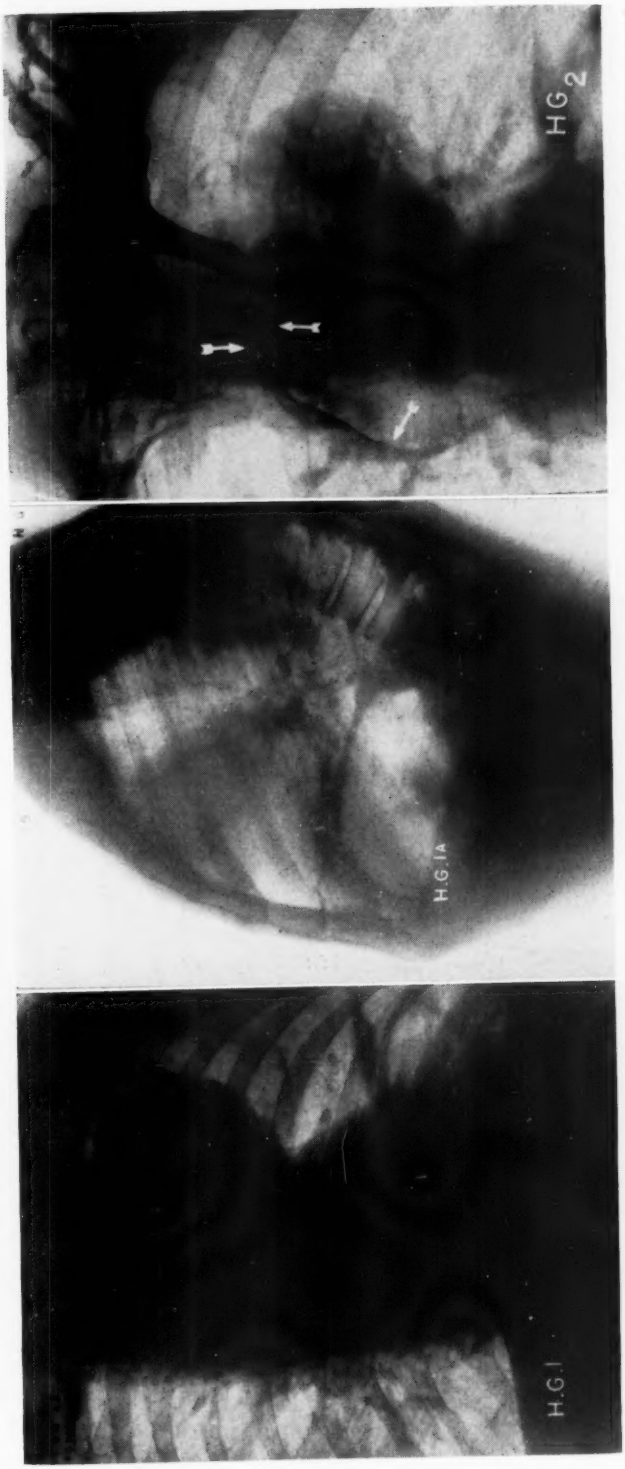

Fig. 3.—"Peripheral" carcinoma of left upper lobe; the neoplasm encroaches upon mediastinum, causing compression, displacement, and infiltration of left innominate vein and superior vena cava.

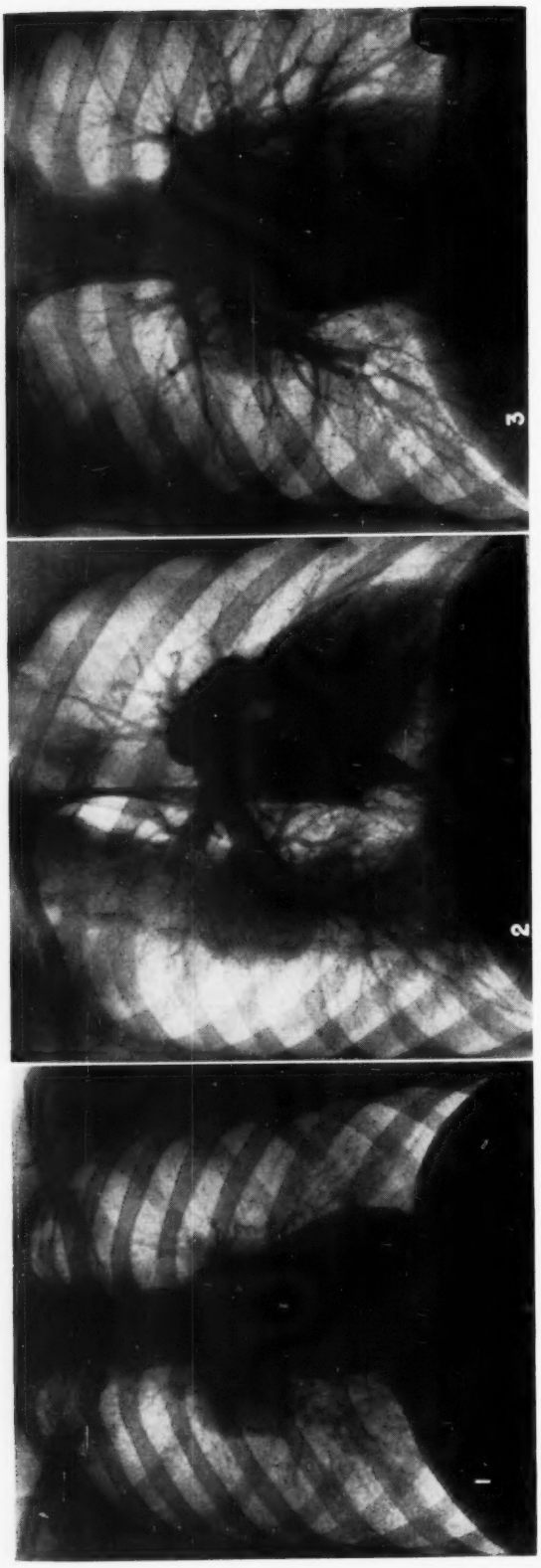

Fig. 4.—Neurofibroma of lung: angiogram reveals no significant abnormality.

SUMMARY

By means of contrast visualization of the pulmonary vascular pattern, certain criteria have been evolved which are of value in the differential diagnosis of the various intrathoracic neoplasms. The main bronchus malignant lesions often involve major branches of the pulmonary artery, causing compression, irregular distortion, and varying degrees of obstruction. In those cases in which the infiltrating lesion arises from a small bronchus, similar changes involving smaller branches of the pulmonary artery are seen. In well-circumscribed tumors, the adjacent vessels are spread apart and encircle the lesion. Mediastinal and pleural lesions cause no significant changes in the angiograms.

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THE EXPERIMENTAL PRODUCTION OF GRADUAL OCCLUSION OF LARGE ARTERIES WITH POLYTHENE AND TANTALUM

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THE problem which the gradual occlusion of large arteries presents is reflected in the fact that since Cooper[1] reported the first case of ligation of the abdominal aorta for aneurysm in 1817 only 36 additional cases have been reported. Of these patients, 8 have survived for one year or more following operation. In this group the aorta was ligated with cotton tape in 5, with fascia lata in 1, and cellophane in 2. Gangrene of the extremities, erosion of the vessel, hemorrhage, recurrence of the aneurysm, and intestinal obstruction as a result of reaction about the ligature material were common postoperative complications in the other cases.

Halsted[2] introduced the use of aluminum and silver bands as a method of aseptically producing a partial occlusion of large vessels. Matas[3] also proposed the use of heavy malleable aluminum bands, which could be applied to large arteries without the use of special instruments, as a means of partial occlusion preliminary to ligation. It was soon recognized that the vessel beneath a band became atrophied, and that the band might quickly erode through the artery. Reid[4] demonstrated the loss of muscular and elastic tissue beneath a band and concluded that partial or complete occlusion of large arteries by this method always leads to death of the vessel wall.

Pearse[5] observed that by wrapping cellophane‡ about the aorta or carotid artery in dogs, a gradual, and at times, a complete obliteration of the artery resulted. He was unable, however, to produce uniformly a complete occlusion of the vessels. The reaction was a profound cellular response, with phagocytic mononuclear cells interspersed among fibrous tissue. This fibrocollagenous layer became partially hyalinized with progressive constriction of the vessel. Harrison and Chandy[6] in 1943 reported the cure of a subclavian aneurysm as a result of fibrosis induced by the use of cellophane wrapped around the vessel. Ten months were required for sufficient occlusion of the vessel to cause diminution in the size of the aneurysm, and nineteen months were required for complete occlusion. Harper and Robinson[7] placed cellophane about a patent ductus arteriosus following its ligation in continuity with silk. The murmur recurred two weeks after operation but again disappeared in two months, and the patient then remained well and without symptoms. The final complete and permanent occlusion was attributed to cellophane. Poppe and de Oliveira[8] in 1946 obtained

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‡DuPont.

encouraging results from the use of cellophane in the treatment of thoracic aneurysms. In 1947 de Takats and Reynolds[9] reported three cases in which they were able to place a band of cellophane about the aorta above the aneurysm. One of these patients survived fourteen months following operation, and another two years. The third died of myocardial failure eight months postoperatively.

Donati, McKeever, and Wheeldon[10 a, b, c] stated that no reaction was obtained to cellophane in their series of cases. Because of this, Poppe and de Oliveira believed that there might be a significant variation in tissue reaction to different types of cellophane. They placed cellophane strips about the abdominal aorta in a series of animals. Only slight reaction was found in any of the animals except those in which the 1.5 mil DuPont polythene was used.

The following experimental procedures were undertaken to utilize a combination of the two methods of occlusion of large vessels, each of which individually has certain inherent disadvantages. It was desired to develop a method which would lead to a gradual and complete occlusion of the vessel, and produce a moderate amount of perivascular reaction, but which would not involve surrounding structures in a fibroblastic process. To accomplish these results, a combination of the cellophane reaction and an initial partial occlusion by a tantalum band was used.

It was believed that tantalum would afford certain advantages over either aluminum or silver in that there is only minimal tissue reaction to it. Carney[11] implanted tantalum plates into the abdominal wall of dogs, and at the end of three weeks no edema or inflammatory change had occurred in the surrounding tissues. These observations have been confirmed experimentally and clinically by other investigators.

METHOD

Tantalum Band and Polythene: Abdominal Aorta (Group A).—Adult mongrel dogs, weighing 7 to 10 kilograms were anesthetized with sodium pentobarbital, 1 c.c. per 5 pounds of body weight, administered intravenously or intraperitoneally. Employing aseptic precautions, a left paramedian or midline incision was made. The posterior peritoneum overlying the aorta was incised and reflected at a site immediately below the origin of the renal vessels. The aorta was isolated and mobilized for a distance of 2.5 cm. at this point. A double thickness of 1.5 mil DuPont polythene* was placed about the aorta as a band 1.5 cm. in width. A Matas band, 1 cm. in width, made of tantalum, was superimposed upon the polythene about the aorta and tightened (Fig. 1). In this manner approximately 60 per cent reduction in cross-sectional area was obtained. The layers of polythene extended 2 to 3 mm. beyond the edge of the tantalum band, preventing contact between the tantalum and the aorta. The peritoneum was replaced over the aorta at the operative site, but was not sutured. The abdominal wound was closed in layers with interrupted sutures of fine silk.

*Polythene 1.5 mil DuPont, code number NV 7-14. The material used in this experiment was kindly furnished by the Cellophane Division, E. I. DuPont De Nemours & Company, Wilmington, Del.

Tantalum Bands Only: Abdominal Aorta (Group B).—A similar procedure was carried out in a group of animals in which the polythene was not used, the tantalum band being applied directly to the wall of the aorta. The band was constricted as in the first procedure.

Tantalum Band and Polythene: Thoracic Aorta (Group C).—A third group of animals was anesthetized with intraperitoneal sodium pentobarbital. The trachea was intubated, and intermittent positive pressure-controlled respirations were maintained. A thoracotomy was performed in the fourth interspace on the left side of the chest. The left upper lobe was decompressed and packed away with moist tapes. The first portion of the descending aorta was identified, and the pleural reflection was incised and dissected away. Approximately 2.5 cm. of the aorta was mobilized. Four layers of polythene and a tantalum band were placed about the aorta in this area, in a manner similar to the procedure employed in Group A. The lung was re-expanded, the air evacuated from the chest, and the chest wall was closed in layers without drainage.

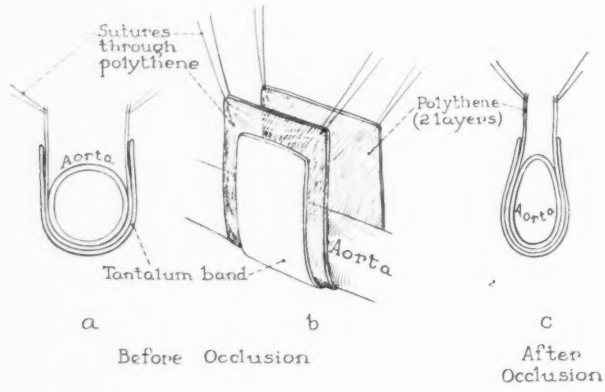


Fig. 1.—Schematic drawing illustrating application of polythene and tantalum band to the aorta.

METHOD OF EVALUATION

Necropsies were performed on all animals in this series, at death or when they were sacrificed. Arteriograms were made in those animals in which the aorta remained intact. In these, the thoracic aorta was cannulated, and Hill's media[12] was injected at mean arterial pressure. Representative specimens were obtained for microscopic examination.

RESULTS

Forty-one animals comprise this series.

Twelve were used as controls in which tantalum bands alone were placed about the aorta (Table I). Four died as a result of hemorrhage due to rupture of the aorta beneath the tantalum band. One animal died of distemper, and at necropsy no increase in occlusion of the aorta beyond the original constriction produced at operation was noted. A complete occlusion of the aorta beneath the band was present in an animal sacrificed at eighteen weeks. The remaining six animals were sacrificed at intervals of twelve to twenty-one weeks following operation. Four of these demonstrated no increase in occlusion, and two only a partial increase in occlusion over the original constriction produced.

TABLE I. GROUP B ANIMALS WITH TANTALUM BANDS ONLY

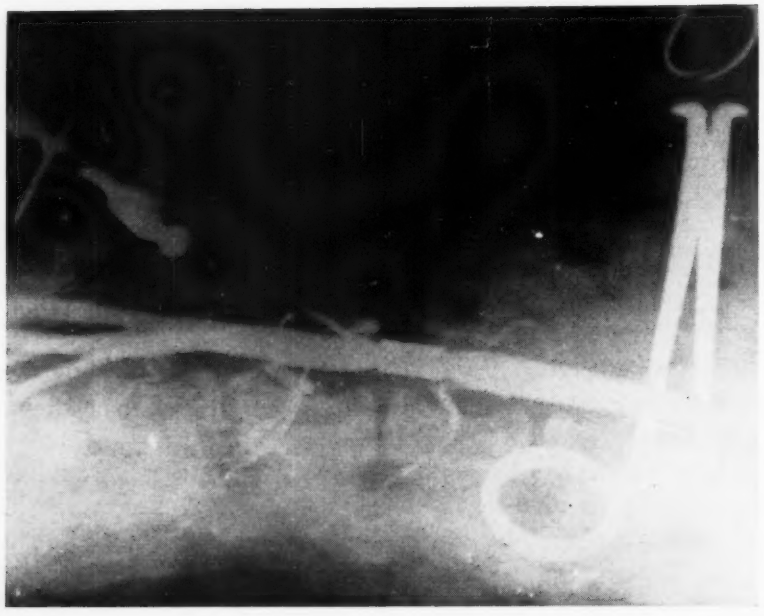
NUMBER OF DOGS	EXPERIMENTAL PERIOD (WEEKS)	RESULTS				
		DISPOSITION	NO INCREASE IN OCCLUSION	PARTIAL INCREASE IN OCCLUSION	COMPLETE OCCLUSION	REMARKS
4	0-3	Died				Hemorrhage due to rupture of aorta
1	5	Died of distemper	1			
7	12-21	Sacrificed	4			
				2		12-14 weeks duration
					1	Complete occlusion 18 weeks

In nineteen animals, two layers of polythene were placed about the abdominal aorta (Table II). A tantalum band was superimposed upon this and tightened (Fig. 2, *A*). A complete occlusion occurred in five of six animals sacrificed from ten to eighteen weeks postoperatively (Fig. 2, *C*), the sixth animal demonstrating almost complete occulsion. Examination of five animals sacrificed from four to eight weeks after application of the bands revealed a partial increase in occlusion (Fig. 2, *B*). There was only one case of rupture of the aorta beneath the band in this group. Four other animals died of distemper before an adequate period for evaluation had elapsed. However, a partial increase in occlusion was present in two. Three additional animals were observed for eight to eleven weeks, but were lost from animal quarters prior to termination of the experiment.

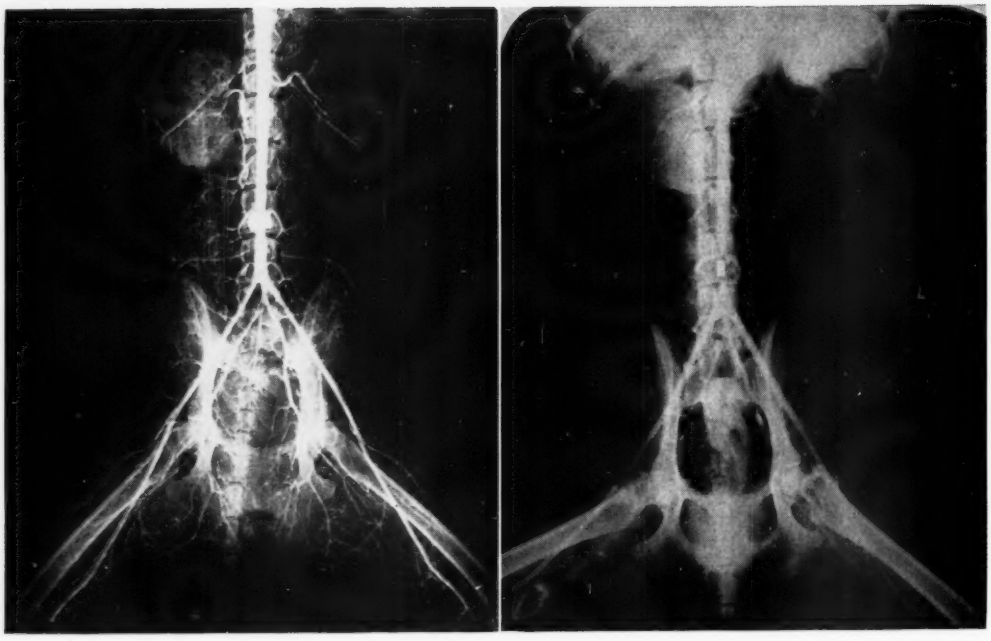
Tantalum bands and polythene were placed about the first portion of the descending aorta in ten animals. Six of these died five to fourteen days postoperatively of hemorrhage due to rupture of the thoracic aorta. In three animals there was no appreciable increase in occlusion at the time of sacrifice one to two months after operation. One animal died seven weeks postoperatively of unknown causes.

TABLE II. GROUP A ANIMALS WITH TANTALUM BANDS AND POLYTHENE

NUMBER OF DOGS	EXPERIMENTAL PERIOD (WEEKS)	RESULTS				
		DISPOSITION	NO INCREASE IN OCCLUSION	PARTIAL INCREASE IN OCCLUSION	COMPLETE OCCLUSION	REMARKS
5	4-8	Sacrificed		5		One animal at 5 weeks demonstrated almost complete occlusion
5	10-12	Sacrificed		1	4	
1	18	Sacrificed			1	
3	8-11	Lost to experiment				Lost from animal quarters; normal postoperative course, however
5	1.5-8	Died	3	2		One of this group had rupture of aorta into descending colon as primary cause of death



A.

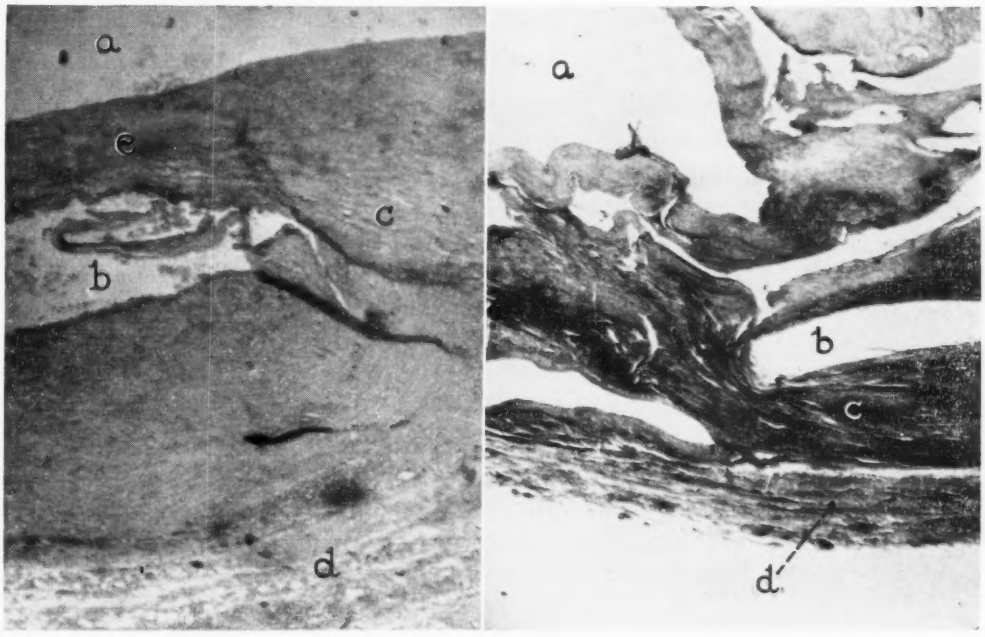


B. *C.*

Fig. 2.—Arteriograms demonstrating (*A*) initial occlusion of the aorta with polythene and tantalum band at operation; (*B*) partial occlusion of the aorta five weeks later; and (*C*) complete occlusion of the aorta twelve weeks later.

DISCUSSION

In all animals sacrificed, there were no neurologic or trophic changes. In each instance, femoral pulsations were palpable prior to sacrifice. Necropsies revealed consistent results. Examination of animals sacrificed at four weeks revealed the metallic band to be covered with fibrous tissue, and none of the metal was exposed to overlying structures. When a section of the aorta was removed at this time, and the fibrous tissue overlying the band was incised, a clear, semigelatinous material was encountered. The band and polythene could then be easily removed from the capsule which had been formed by the fibrous tissue. There was no tendency for the aorta to adhere to either the band or the polythene. In animals sacrificed after greater intervals, it was found that the



A. *B.*

Fig. 3.—Photomicrographs of longitudinal section of aorta occluded by (*A*) polythene and tantalum band; (*B*) tantalum band only; *a*, aortic lumen; *b*, sinus occupied by occluding material; *c*, fibrous tissue around sinus; *d*, adventitia; *e* (*A*), pressure atrophy.

occlusion of the aorta had become more complete, and the amount of fibrous tissue had increased. There was a corresponding decrease in the amount of gelatinous exudate about the band and metal. At the end of twelve weeks, occlusion of the aorta was complete. In each instance the metallic band was completely encased in fibrous tissue. At the margins of the band, where erosion was prone to occur, there was an actual re-enforcement of the arterial wall due to thickening of the adventitia which merged imperceptibly with the fibrous tissue about the band (Fig. 3, *A*). In the control series, in which a tantalum band was applied directly to the wall of the aorta, there was only a minimal fibroblastic reaction at the margins of the band (Fig. 3, *B*).

CONCLUSIONS

In these experiments a partial occlusion of the aorta was produced in the initial operation through the use of a metallic band. The subsequent complete occlusion was the result of the fibroblastic cellular response produced by polythene. Through the use of a metallic band to aid the obturation of the vessel lumen, it was possible to use smaller quantities of polythene, to produce a more rapid occlusion of the vessel, and to reduce the extent of the perivascular reaction. It is believed that the fibrosis produced by the polythene serves to protect the vessel from erosion of its wall by the margin of the metal band. Microscopically, it is readily appreciated that a heavy buffer of fibrous tissue is produced at the margin of the band and extends along the course of the artery as a bulkhead against erosion and aneurysmal formation in this region. The vessel beneath the band continues to atrophy, but the entire area is encased in a sheath of fibrous tissue.

SUMMARY

1. A method of gradual occlusion of large arteries using a tantalum band and polythene is presented.

2. The use of a metallic band and polythene overcomes the inherent disadvantages of either material alone.

3. A partial occlusion of the artery is immediately produced by the metallic band, and the period of time required for complete occlusion of the artery is greatly decreased.

4. The fibrosis stimulated by the polythene produces a gradual constriction of the artery and results in the formation of fibrous tissue about the band. This mass of fibrous tissue acts to prevent erosion of the wall of the artery or aneurysmal formation.

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VASOMOTOR CHANGES IN PERIPHERAL NERVE INJURIES

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IN THE period between World Wars I and II, adequate investigations of the circulation of a limb following injury to a peripheral nerve have, causalgia excepted, been few, and occasional references have been found in the literature available to us. Lewis and Pickering,[1] Highet,[2] Lewis and Landis,[3] Grant and associates[4, 5] Atlas, [6, 7] Holmes and co-workers,[8] studied, in the course of investigatons on the peripheral circulation, some effects of peripheral nerve block or section.

It is not until 1946, however, that a thorough account of the vasomotor changes in nerve injuries can be found, by Richards.[9, 10]

In a personal series of 111 cases of peripheral nerve injury, certain inquiries into the nature of the vasomotor changes were made in some of the cases, and the results are recorded. First, a series of normal, healthy adults were studied to determine normal vasomotor reactions. In a further series of normal persons, procaine block of peripheral nerves provided excellent examples of early effects of complete nerve interruption. Some studies were made on cases of complete and irrecoverable nerve lesions, on cases of partial nerve lesions, and finally on recovering lesions.

Clinical indications of the state of the peripheral circulation are well known. More accurate information is, however, obtainable by the use of some apparatus. A plethysmograph was used in a few cases where a complete digit was involved, and a dermohmeter was used to determine skin resistance. For our purpose, however, a sensitive instrument employing a lightbeam galvanometer was used to determine the skin temperature of the area studied.

If the environmental temperature remains constant, then it is reasonable to assume that a rise in skin temperature will indicate an increase in blood flow (vasodilatation) and a fall in skin temperature a decreased blood flow (vasoconstriction) in the cutaneous blood vessels. Further changes in blood flow at extremes of vasodilatation and vasoconstriction can be recorded only by plethysmography, but for the purpose of this study skin thermometry was sufficient.

THE VASOMOTOR EFFECTS OF PERIPHERAL NERVE DIVISION

After division of a peripheral nerve, the vasomotor state passes through two phases: The initial stage is one of vasodilatation, due to the interruption of the sympathetic vasoconstrictor fibers contained in the nerve. This is often known as the "warm phase."

This is a temporary phase, lasting usually not longer than about three weeks. It is followed by a second and more permanent stage, in which the tem-

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perature of the denervated area corresponds to that of its environment. This is the "cold phase."

The immediate effects of division of a peripheral nerve can best be illustrated by procaine block of the nerve. Fig. 1 illustrates the case of a normal, healthy, adult male, in whom first the ulnar and then the median nerve were blocked by 2 per cent procaine injection at the level of the elbow. There was a rapid rise of temperature, indicating a release of normal vasoconstrictor tone over the autonomous sensory zone of the nerve. (Note that in Fig. 1, and in all graphs following, the room temperature is indicated by a straight line. Room temperature varied slightly during these experiments, but it was kept relatively constant—the straight line indicates the average room temperature.) Clinically the affected area is hot, flushed, dry, and does not sweat.

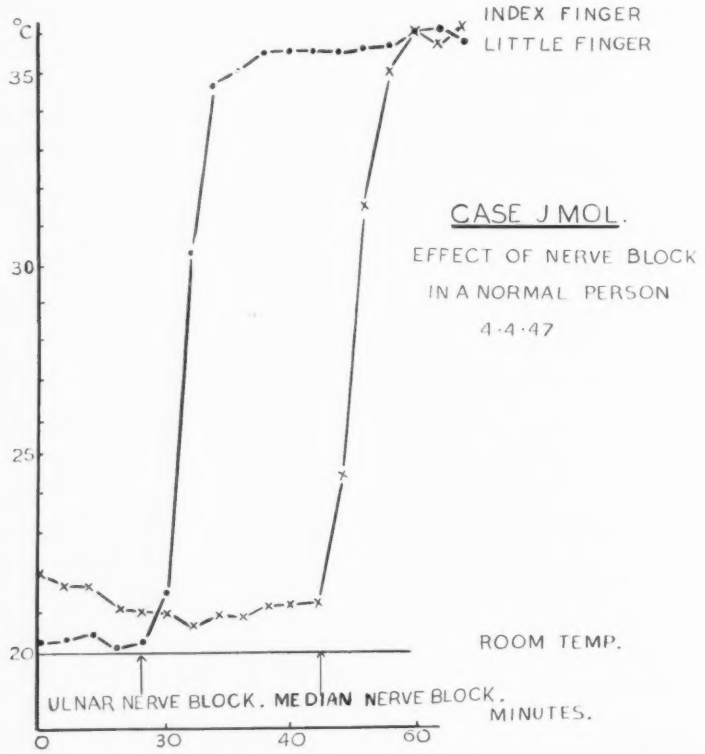

Fig. 1.—Showing the effect of ulnar, followed by median, block with 2 per cent procaine hydrochloride, on skin temperature of digits. (Temperature in degrees centigrade, time in minutes. This pertains in all similar charts in this paper.)

Fig. 2 illustrates the state of the blood vessels in Case DOO, a native who received a stab wound of the left brachial plexus on June 1, 1947. When first seen, the left hand was still warmer than the right, and Fig. 2 shows the skin temperatures on June 7, 1947, six days after injury.

This warm phase does not persist, however, and after a period varying from ten days to six weeks, the affected part becomes colder than the adjacent part. If the nerve is not repaired, or no regeneration occurs, this state of affairs

remains permanently, and only local influences (humoral and thermal) will affect the state of the blood vessels.

Figs. 3 and 4 indicate the state of the circulation in Case DOO. It will be noted that the transition from the warm to the cold phase has taken place in approximately twenty-one days.

It has been found that there is great individual variation in the time of appearance of the cold phase. In one patient (seen after this series was closed), the warm phase ended after the first week.

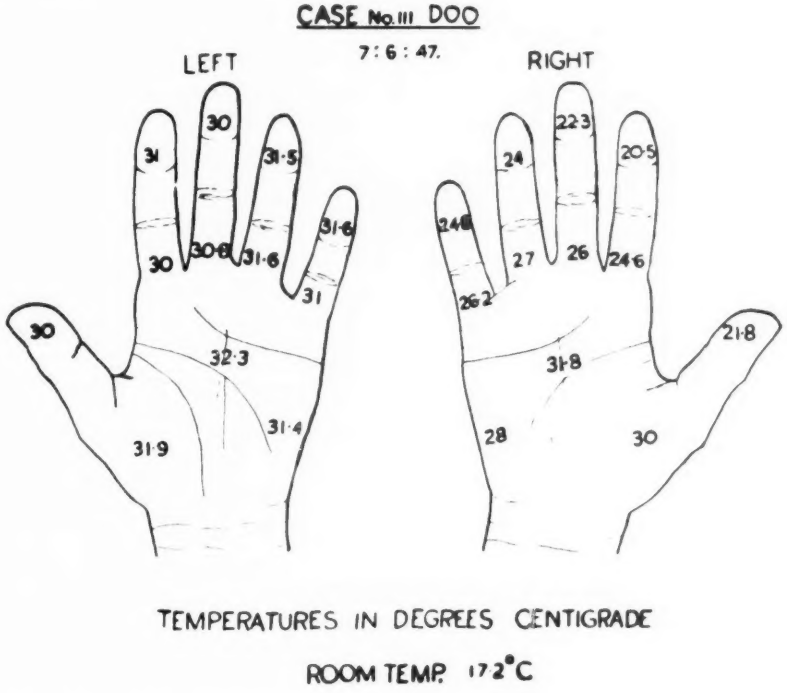

Fig. 2 (Case DOO).—Skin temperatures of the hands six days after left total brachial plexus lesion (stab wound). Note higher temperatures on the left.

Grant and associates[4] have found that the vessels of the rabbit's ear regain some tone five to seven days after denervation.

In the first or warm phase, the state of the vessels is stable, and the skin temperature will not fall if the body is cooled, nor will it rise if the body is warmed.

In the second or cold phase, the skin temperature will again not vary with reflex heating or cooling of the body. The vessels will respond, however, to local cooling and heating. The part involved takes on the temperature of the environment like an inert body.

REFLEX VASOMOTOR ACTIVITY

Reflex vasomotor activity may be investigated by recording skin temperature before and after heating or cooling the body or other limbs, and local reactions of blood vessels may be determined by recording the temperatures, for example, after immersing the part in cold water. The nature of reflex vasomotor

activity should be discussed first. It has long been known that warming a part of the body will lead to the rise in temperature of parts not warmed. Similarly cooling a part results in reflex cooling of other parts of the body.

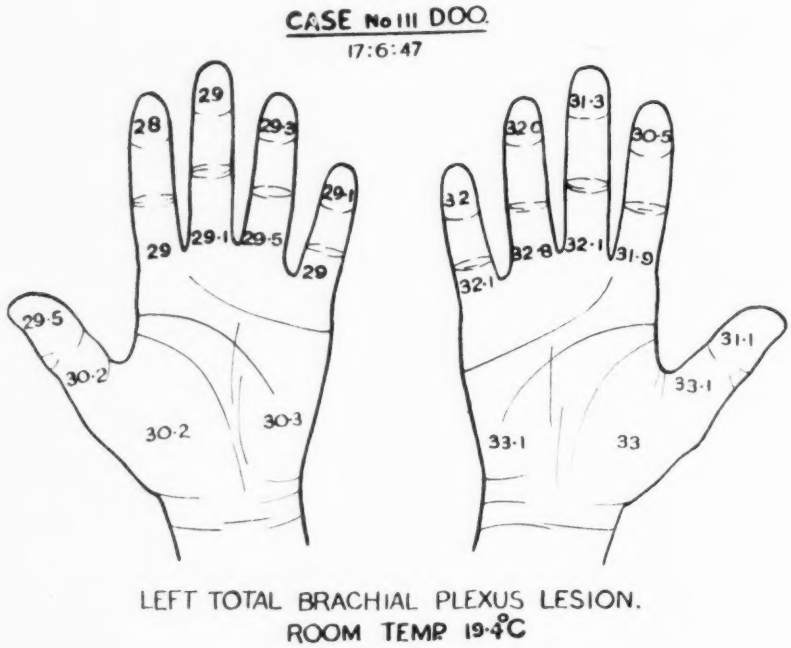

Fig. 3 (Case DOO).—Skin temperatures of the hands sixteen days after left total brachial plexus lesion.

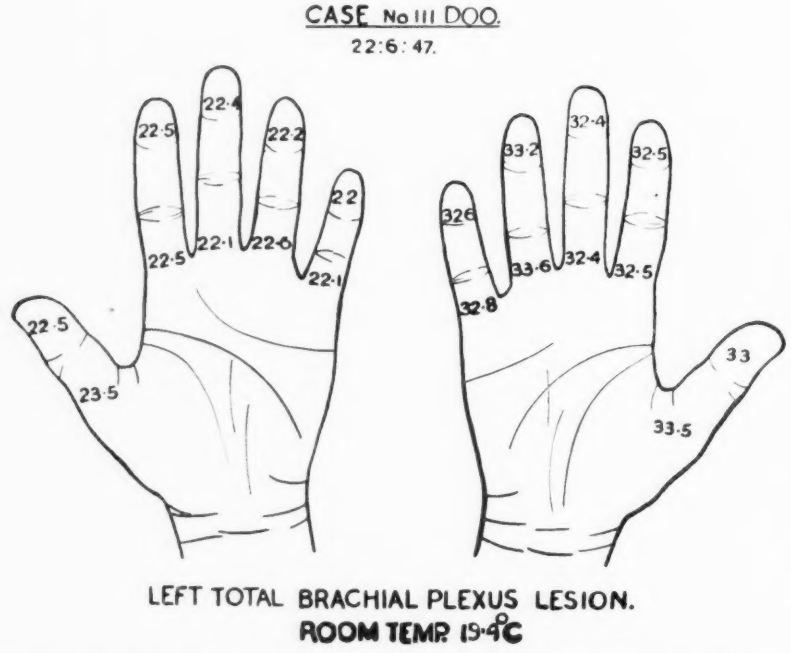

Fig. 4 (Case DOO).—Skin temperatures of the hands twenty-one days after left total brachial plexus lesion. Note low temperatures on the left side at this time.

In these investigations, patients were placed in a room at a more or less constant temperature for at least one-half hour before the test began. They were placed reclining on a bed, or, if the feet were immersed, sitting. When it was considered that the skin temperature had adapted itself to that of the room, the test began. To obtain reflex heating, the feet or arms were placed in baths, the temperature of the water being kept constant by thermostat electrical heating, and to obtain cooling, the feet or arms were placed in baths of cold water in which cubes of ice were melting. This gave the desired temperature of 15° C. while for warming the limbs were heated to about 45° C.

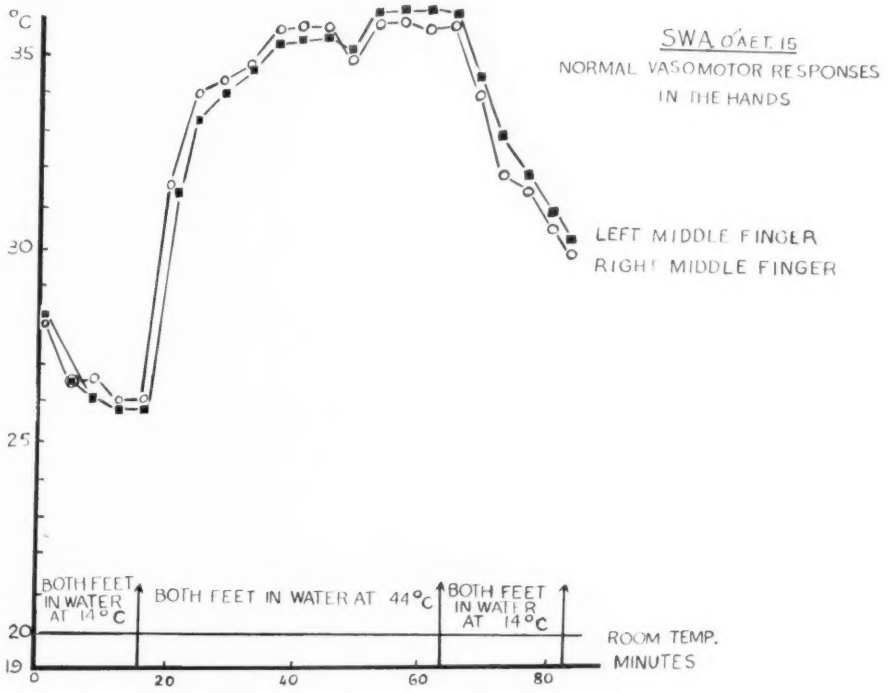

Fig. 5.—Normal vasomotor response in the hands after immersion of both feet in water at 44° C.

Fig. 5 indicates a normal vasomotor response in the hands after immersion of the feet, while Fig. 6 shows a normal response in the foot after immersion of the hands and forearms. The nature and cause of this vasodilatation has been the subject of some controversy. It may be due either to reflex nervous stimuli set up at the site of warming or to the warmed blood from the immersed extremity.

A very striking case which provided an opportunity for studying this problem was that of REE. This young lad was involved in a motor accident, and sustained a compound fracture of the right tibia and fibula, multiple fractures of the right forearm, and a total avulsion of the right brachial plexus (confirmed by exploration).

There was total paralysis of all the muscles of the right upper extremity, and total anesthesia of the arm, except for a small area on the inner side of the upper arm, corresponding to the zone of the intercostobrachial nerve. When examined, he was already in the cold phase. Immersing the feet in warm water caused a normal vasomotor response in the left hand, but, as was to be expected, no response in the denervated hand (Fig. 7).

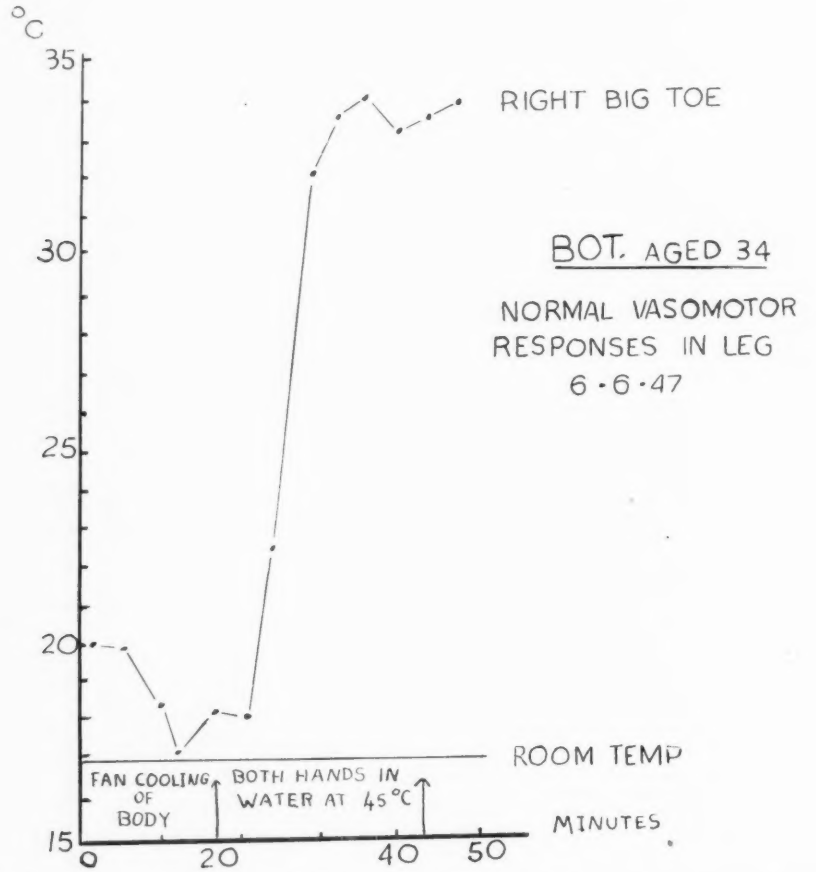

Fig. 6.—Normal vasomotor response in right foot after immersion of both hands and forearms in water at 45° C.

On another occasion, the effect of immersing the anesthetic arm was tried. The totally denervated hand and forearm were immersed in hot water, and, as seen from Fig. 8, normal vasomotor responses were obtained in the normal hand and foot.

There was no possibility of nervous impulses being conveyed, and the effect must have been due to the warmed blood flowing from the immersed limb. To substantiate this, the anesthetic arm was immersed in hot water, with a baumanometer cuff applied and inflated to above systolic blood pressure. There was no response from the normal limbs, but, as soon as the pressure in the cuff was released, reflex warming soon occurred (Fig. 9). This confirms that it is

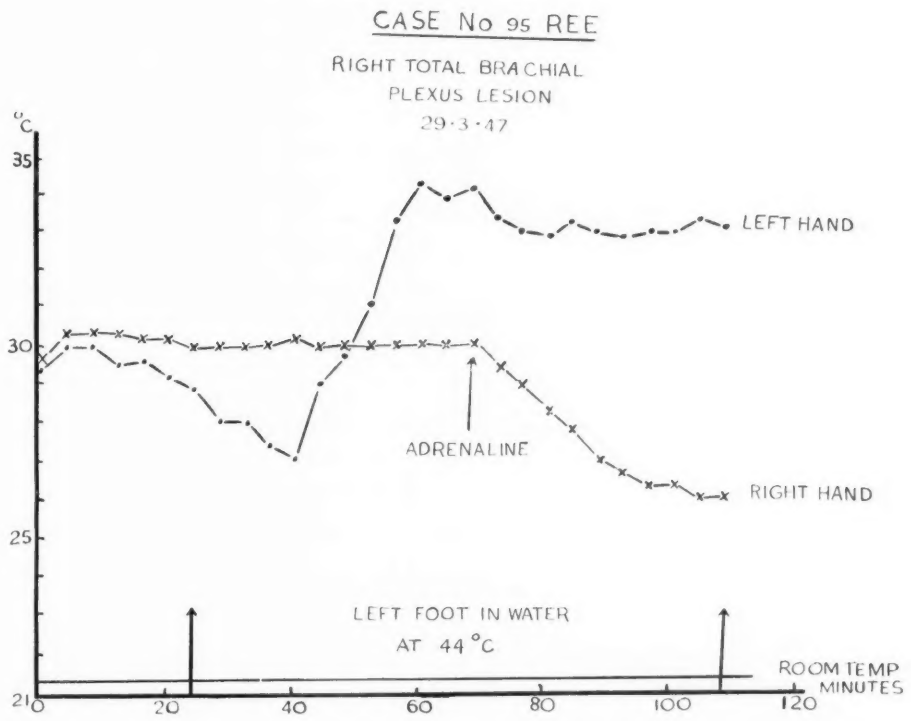

Fig. 7 (Case REE).—Right total brachial plexus lesion; normal vasomotor response in left hand, no response in right hand. (The action of adrenalin is explained in Fig. 21.)

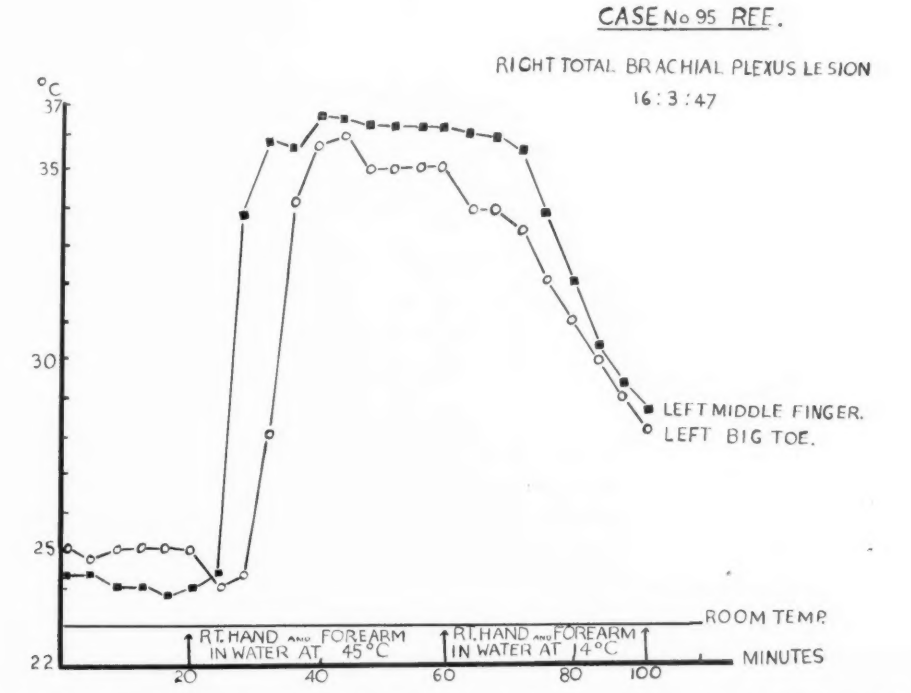

Fig. 8 (Case REE).—Same case as in Fig. 7. Normal vasomotor responses in the normal hand and foot on immersing the totally anesthetic left hand and forearm in warm water.

the warmed blood flowing from the extremity which is responsible for the reflex vasodilatation.

The stimulus which gives rise to the vasodilatation is presumably the warmed blood acting on the vasomotor center.[11, 12] With cooling, a reflex nervous mechanism may play a small part. Pickering[12] stated that there is an immediate reflex vasoconstriction on applying a cold stimulus to the skin. This, is, however, very transient, and the vasoconstriction resulting from prolonged application of cold is due in part to a central mechanism excited by the cooled blood returning from the skin. Gibbon and Landis[11] have noticed a conspicuous vasoconstriction in the hand if the other arm is placed in cold water, even with arrested circulation. The main effect appears, however, to be that of the cooled blood on the vasomotor center.

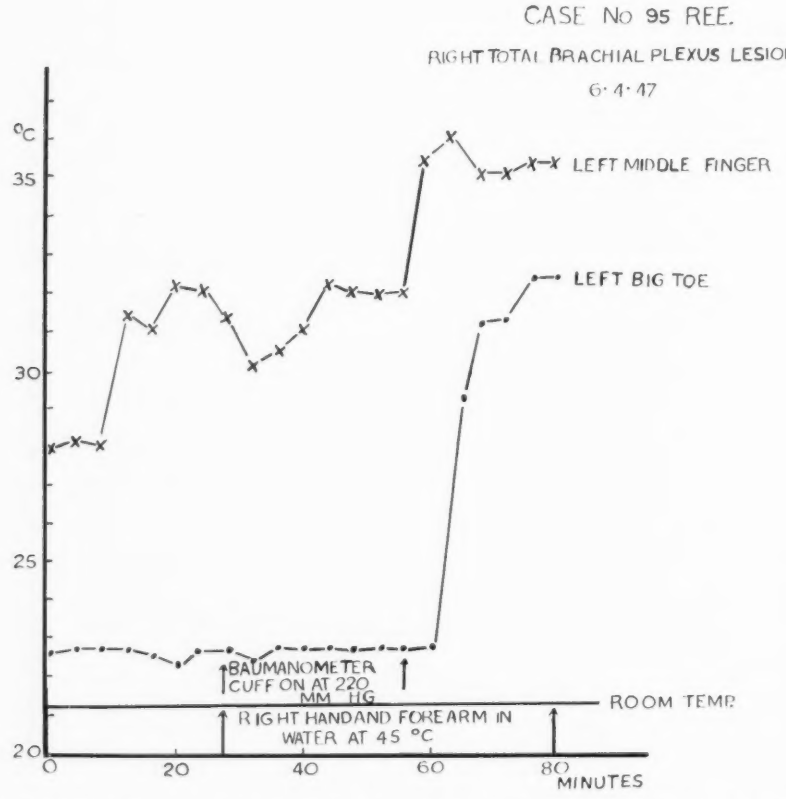

Fig. 9 (Case REE).—Same case as in Figs. 7 and 8, showing effect of immersing the denervated limb in water at 45° C., with the circulation occluded and then re-established.

THE VASOMOTOR REFLEXES IN THE COLD PHASE

The vasomotor reflexes in the "cold phase" are studied in complete nerve lesions, where no recovery has occurred, or in patients seen soon after their entry into the cold phase. The response to reflex warming and cooling is absent. There is complete failure of the denervated parts to respond to reflex warming. One must make the reservation, however, that digits receiving a double nerve supply may show an almost normal response. For instance, in a median nerve

lesion, the fourth finger may show a normal response by virtue of ulnar nerve overlap, while only the index and middle fingers will show complete absence of response. The thumb may again show a certain degree of response, due to overlap from the radial nerve.

The following charts are representative of the cases examined. Fig. 10 shows the vasomotor responses in Case DOO. This patient received a stab wound of the left brachial plexus, and the examination was made after he had entered the cold phase, twenty-one days after the injury.

In this case, an unusual feature is to be noted. Usually, the normally innervated digits will respond by vasodilatation within ten to fifteen minutes after immersion of the feet in hot water. In this case, however, the response did not take place until the feet had been immersed for seventy-five minutes, and this in the absence of organic vascular disease in the feet or hands.

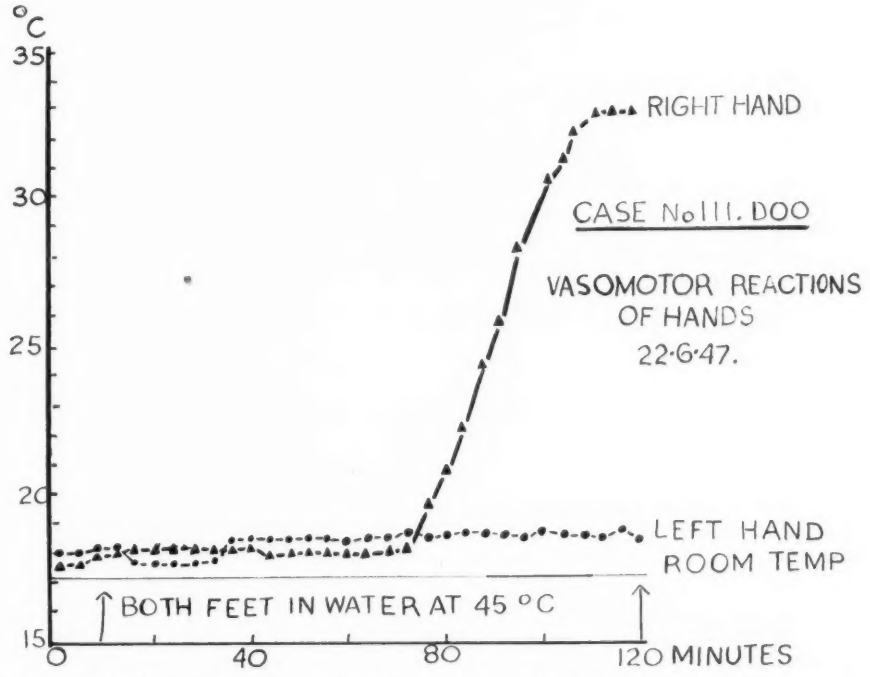

Fig. 10 (Case DOO).—Total left brachial plexus lesion. Note late onset, but good reaction in normal hand, and no response of denervated hand.

During the course of this investigation, an interesting finding was observed in a case of a total ulnar nerve lesion. This was a young native girl (Case MAL) who sustained a laceration of the left upper arm on Dec. 10, 1946. During the débridement, the house surgeon inadvertently snipped off a portion of the already divided ulnar nerve. At subsequent exploration on Jan. 31, 1947, a gap of 12 cm. was found. This was impossible to suture and no graft was performed.

The area of sensory loss is illustrated in Fig. 11. The resting skin temperatures are shown in Fig. 12.

Fig. 11 (Case MAL).—Total left ulnar nerve lesion, sensory loss shown. Continuous line shows absence to light touch, interrupted line absence to pin prick.

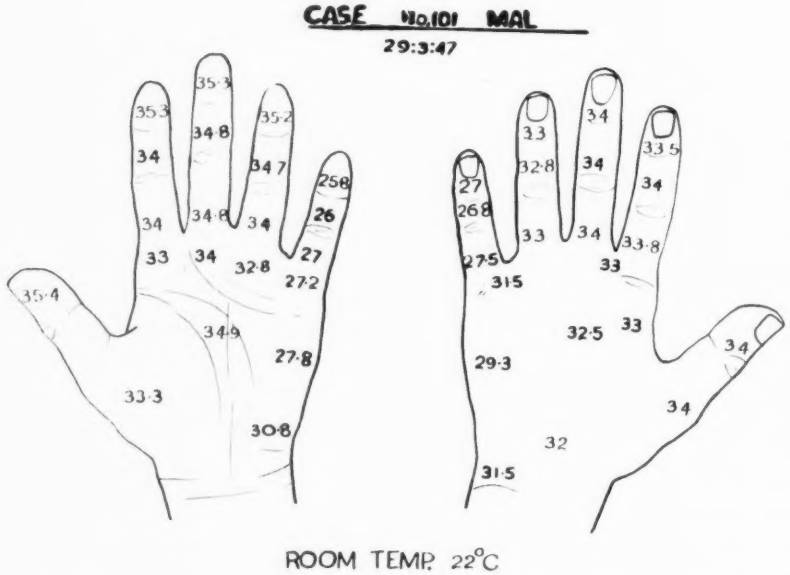

Fig. 12 (Case MAL).—Same case as in Fig. 11, showing resting skin temperatures. Note low temperatures on little finger and hypothenar edge.

There was thus no question of the completeness of this ulnar nerve lesion. However, in the course of investigating the reflex vasomotor responses, it was found that there was some response in the denervated little finger (Fig. 13).

This finding, then, indicates that there must be some intact vasomotor fibers to the left little finger. How do these fibers reach the finger? The ulnar nerve lesion was proved to be a complete one.

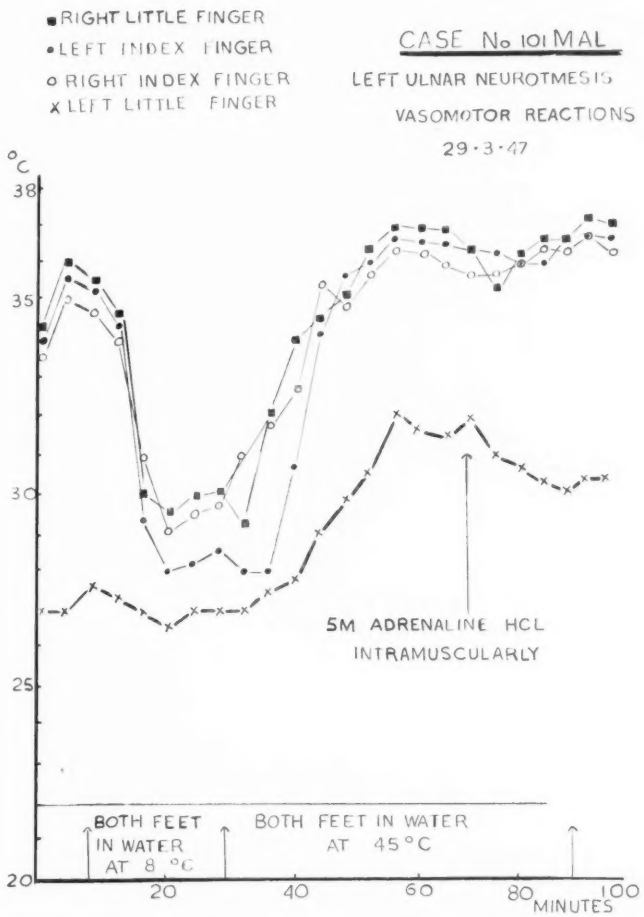

Fig. 13 (Case MAL).—Same case as in Figs. 11 and 12. Note the left little finger in the cold phase, although the temperature is higher than that usually found. The other fingers, as indicated, were used as controls. Note, on reflex cooling, a fall in temperature of all the normally innervated digits, and a slight fall in that of the denervated finger. At this time, on reflex warming, the temperature of the normal controls rises to full vasodilatation level, while that of the denervated finger rises, more slowly, and to a lower level than the normals.

A further experiment was then performed (Fig. 14). First the *left* ulnar nerve was blocked with procaine, at the wrist, to exclude the possibility of nerve fibers having reached the ulnar nerve trunk from the median in the forearm. There was, of course, no absolute proof of this block, but one could be reasonably certain of it.

On reflex cooling, there was a vasoconstrictor response in the normal digits, and a slighter response in the little finger. On reflex heating, there was again

a response of 3° C. in the little finger. The *left median* nerve was blocked at the wrist. On reflex cooling, followed by heating, normal responses were noted in the normal right little finger (control), no response in the normal left index (vasoconstrictors now paralyzed), and no response in the left little finger.

This indicates, then, that in a proved complete ulnar nerve lesion, some degree of vasomotor response was still present in the anesthetic little finger, and that these vasomotor fibers reached the finger by overlap from the median nerve in its ultimate distribution.

The question of overlap of vasomotor nerves could also be illustrated in Case DUP. The radial digital nerves of the left index and middle fingers of a staff nurse had been divided on April 8, 1947. Primary suture was performed with human hair.

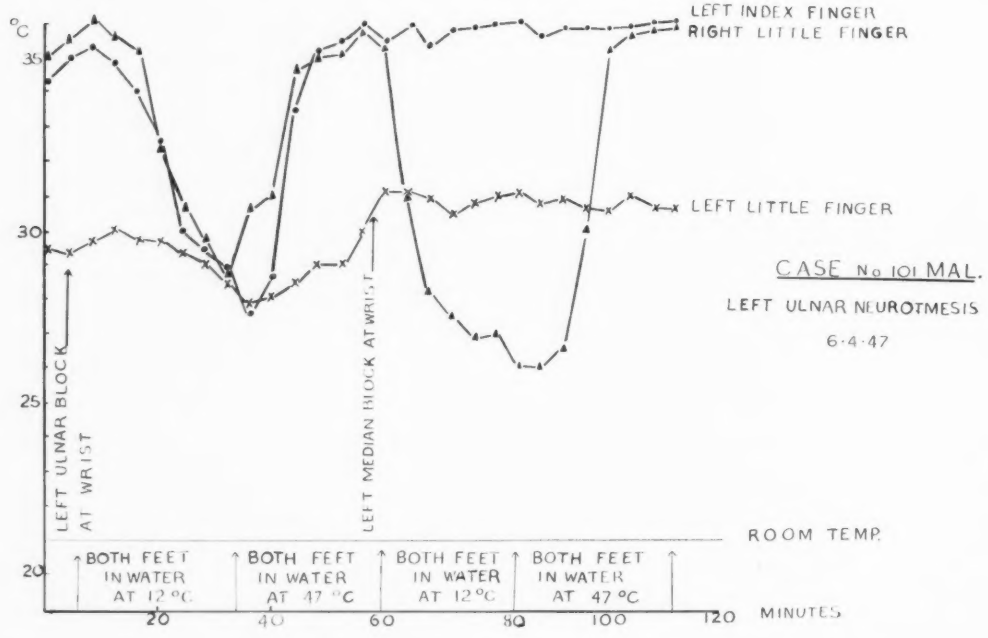

Fig. 14 (Case MAL).—Same case as Fig. 13. Left ulnar, followed by left median, block with 2 per cent procaine hydrochloride. (See text for explanation.)

Fig. 15 shows the resting temperatures five days later. Note the denervated halves of the involved fingers still in the warm phase, the temperature being higher than that of the normally innervated halves. This temperature is, however, not up to full dilatation, probably due to some vasoconstrictor tone remaining by overlap from the adjacent digital nerves. Nor is the initial temperature of the normally innervated halves down to that of the unaffected control fingers. This is probably due to a certain degree of vasodilatation due to vasocontrictor paralysis of nerves overlapping from the denervated areas.

Fig. 16 shows the reflex vasomotor responses. Note normal response of normal little finger on reflex warming, and response of all other areas, the final temperature of the denervated halves of the digits not reaching, however, the high values of the normally innervated skin.

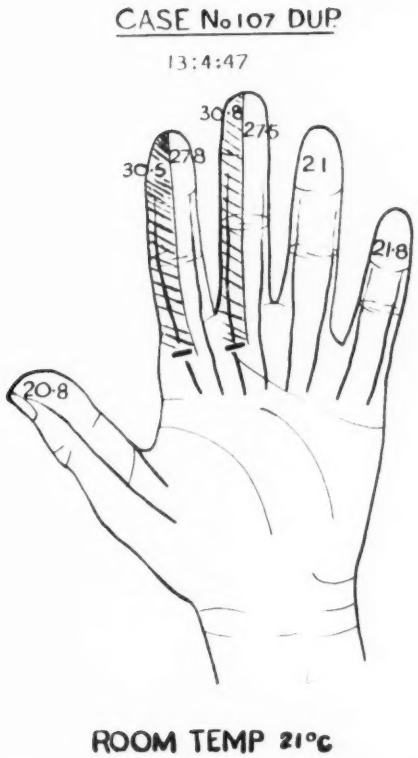

Fig. 15 (Case DUP).—Division of digital nerves on radial sides of left index and middle fingers. Resting temperatures shown in degrees centigrade. (See text.)

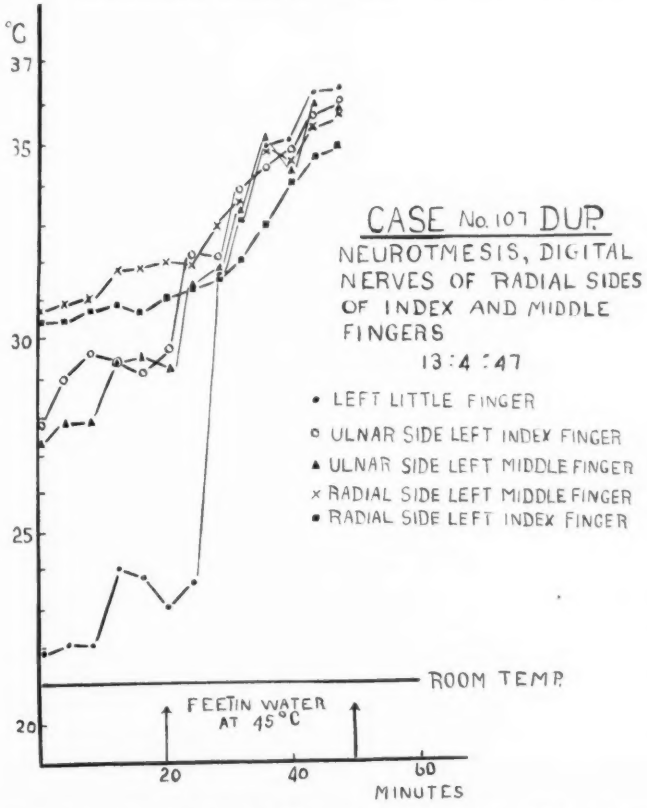

Fig. 16 (Case DUP).—Same case as in Fig. 15, showing the reflex vasomotor responses. (See text.)

Fig. 17 shows normal responses twenty days after injury, probably due to rapid return of function of vasomotor nerves from adjacent overlap.

THE RESPONSE TO LOCAL CHANGES IN TEMPERATURE

The effect of local temperature was determined in the cases available by immersing the limb in cold water. Measurement of the temperature could not be maintained continuously during immersion, nor could readings below 15° C. be obtained. The manner of performing these experiments was thus not as satisfactory as one would have wished, but the charts shown in Figs. 18 to 23 will give an indication of the effects to be expected.

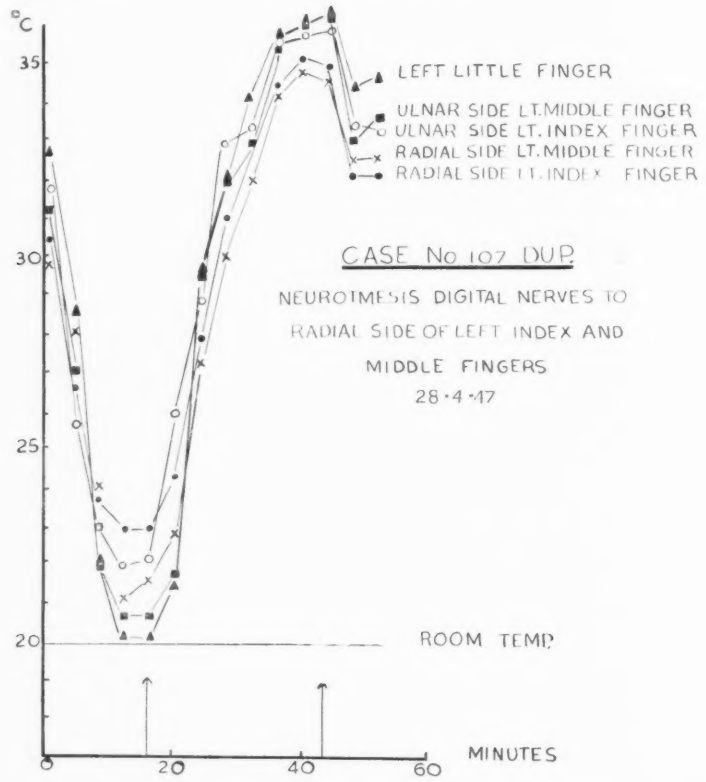

Fig. 17 (Case DUP).—Same case as in Fig. 16, showing practically normal vasomotor responses twenty days after injury.

Fig. 18 shows response to local cold in a case of complete right brachial plexus lesion. Note that the initial temperature of the denervated hand is lower than that of the normal. Local cooling produces a marked fall in temperature, with a subsequent rapid rise in the normal hand, and a more gradual rise in the denervated hand.

One patient (Case WEL, Fig. 19) sustained a total median nerve lesion, and a secondary suture was performed. The reaction to local cold shows again a marked drop in temperature, followed by a rapid rise of the temperature of the normal fifth digit, and a slower and less complete rise in the denervated second digit.

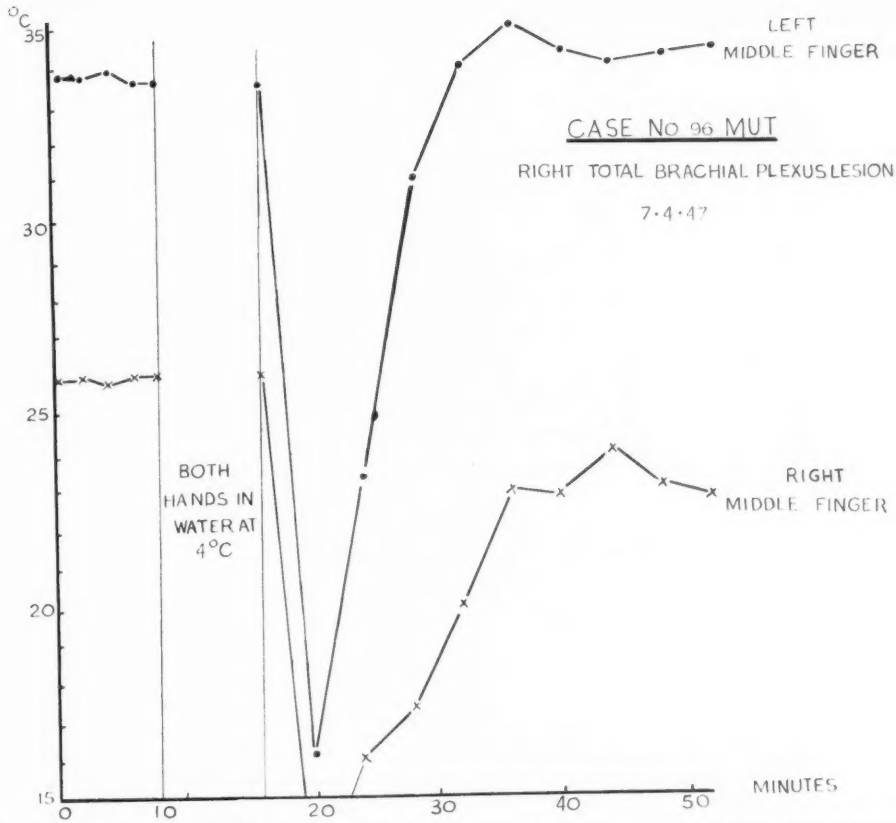

Fig. 18 (Case MUT).—Right total brachial plexus lesion. Vasomotor reactions in response to direct immersion of both hands in cold water at 4° C.

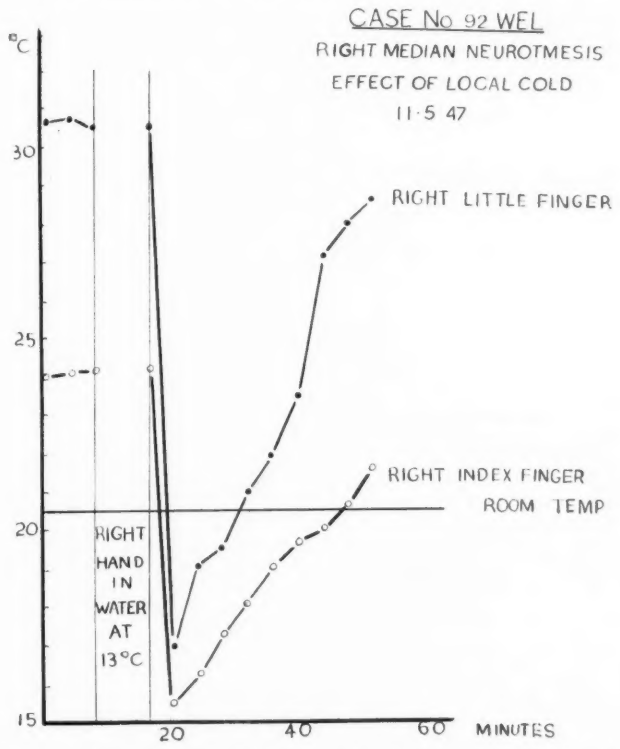

Fig. 19 (Case WEL).—Right total median nerve lesion, responses to direct cooling of hands by immersion in cold water.

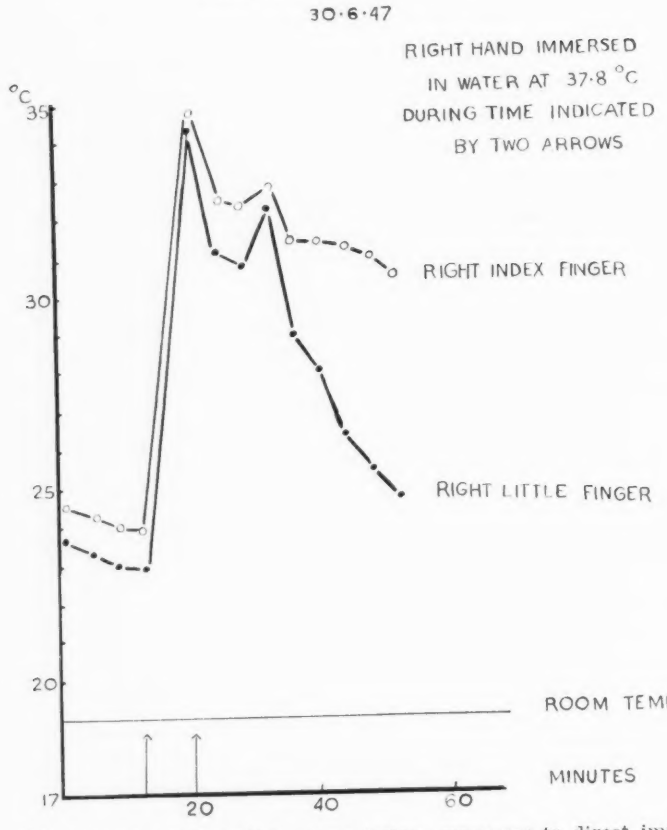

Fig. 20 (Case JOH).—Right total median nerve lesion, responses to direct immersion in warm water.

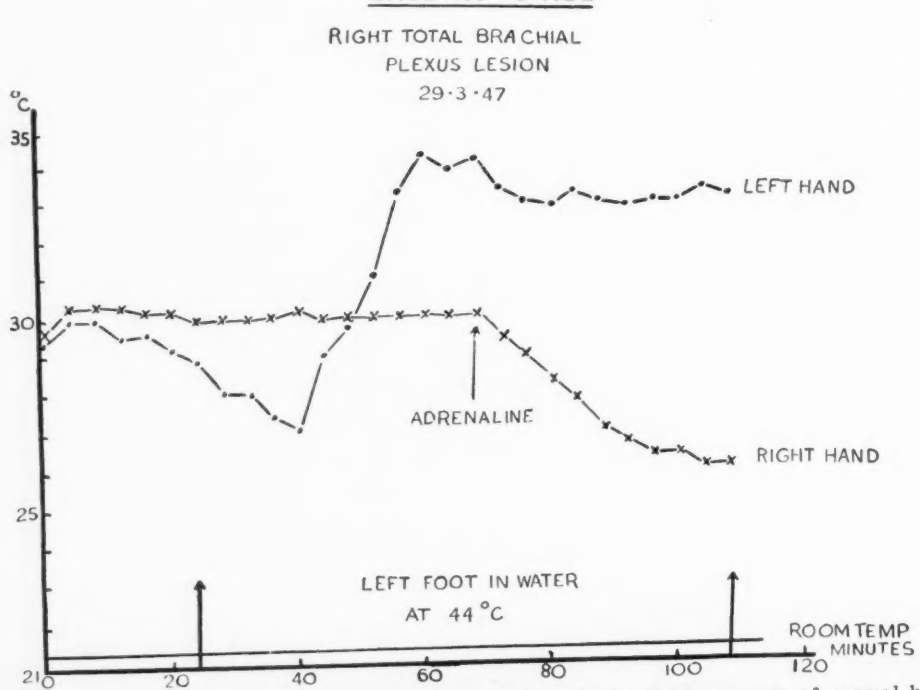

Fig. 21 (Case REE).—Right total brachial plexus lesion. Note slight response of normal hand to adrenalin, and marked fall in temperature of denervated hand.

No observations have been possible in the warm phase of a denervated digit. Richards[9] found that denervated digits do not cool significantly on exposure to cold. Fig. 20 shows the response of local warming on a denervated digit.

THE EFFECT OF ADRENALIN ON DENERVATED BLOOD VESSELS

A satisfactory explanation of why a digit affected in peripheral nerve division should go into a cold phase at all has not been offered. Many suggestions of causative factors have been put forward, a popular one being that small amounts of circulating adrenalin cause contraction of blood vessels, the denervated vessels being more sensitive to such quantities of adrenalin than innervated vessels.

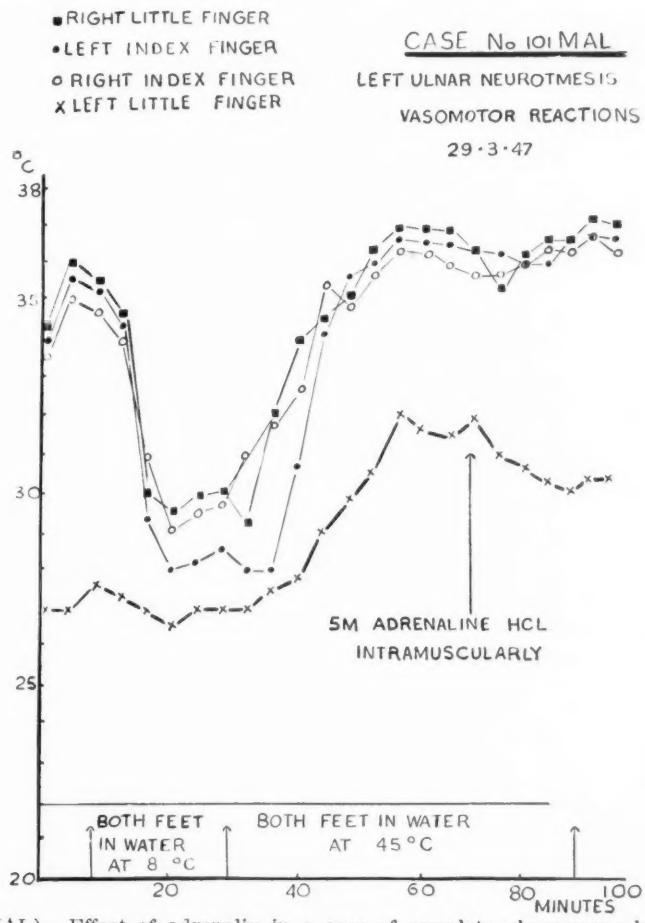

Fig. 22 (Case MAL).—Effect of adrenalin in a case of complete ulnar nerve lesion, but where an "overlap supply" from the median nerve could be demonstrated.

Fig. 21 shows the effect of adrenalin on a totally denervated hand. This case had a complete brachial plexus lesion, proved by operation. The vasomotor responses are shown. There was absolutely no response from the denervated hand, until after the injection of 5 minims of 1 in 1000 adrenalin intramuscularly, when a fall of 4° C. could be registered.

Fig. 22 illustrates the effect of adrenalin on the little finger in a case of complete ulnar nerve lesion, but where an overlap of vasomotor fibers from the median nerve could be demonstrated. There is a small but signicant drop in the temperature of affected finger and no drop in that of the control fingers.

Fig. 23 illustrates a definite but negligible effect of adrenalin on normal blood vessels, fully dilated. Fig. 29, shows that, in a recovering lesion, the skin temperature did not drop, but there was marked blanching of the digit, indicating an effect on the capillaries. This blanching did not occur in normally innervated fingers.

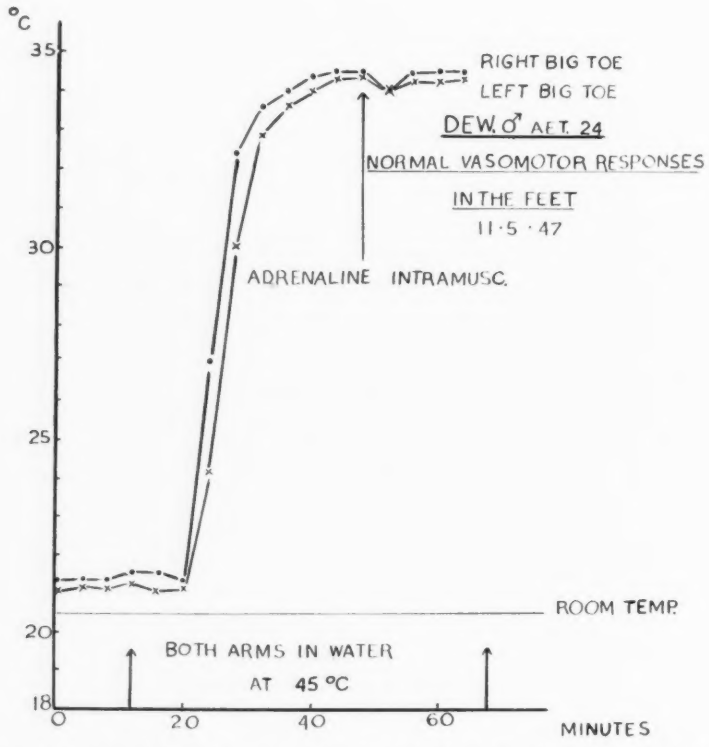

Fig. 23.—Effect of adrenalin on normal fully dilated blood vessels; the effect is negligible.

In Fig. 7 the action of adrenalin on the normal left hand is negligible, compared with the marked fall in temperature of the denervated hand. In Fig. 13 the action of adrenalin on a partially denervated finger is shown. At the same time, it can be seen that the action on normally innervated digits at full vasodilatation is absent or negligible. In Fig. 25 the acton of adrenalin on normal control digits at full vasodilatation is seen to be absent. Fig. 29 shows complete absence of action of adrenalin on normal control digits at full vasodilatation.

It appears, therefore, that adrenalin exerts little effect on normal vessels at full vasodilatation, whereas it causes a contraction of denervated blood vessels. Further, it has been shown[13] that vessels subjected to a postganglionic sympathectomy are much more sensitive to adrenalin than if a preganglionic

section had been carried out. Division of a peripheral nerve divides the postganglionic sympathetic fibers, and the denervated vessels would therefore be excessively sensitive to circulating adrenalin.

PARTIAL NERVE LESIONS

It is to be expected that incomplete nerve lesions will cause a certain number of nerve fibers, including vasomotor fibers, to remain intact, and that there will therefore be a certain amount of vasomotor activity in the autonomous zone of the nerve.

These lesions, whether they be neurotmesis, axonotmesis, or neurapraxia, will cause the same picture of complete or partial vasomotor activity. Description of some illustrative cases will best demonstrate the findings to be expected.

Fig. 24 (Case KLE).—Partial median nerve lesion; sensory loss illustrated. Continuous line shows area of loss to light touch, interrupted line shows area of loss to pin prick.

A woman 28 years of age, Case KLE, sustained a wound of the right median nerve. The sensory loss is shown in Fig. 24. By procaine block of the various peripheral nerves of the arm, it was established that this was in fact a partial median nerve lesion and not a complete lesion with extensive ulnar nerve overlap.

Figs. 25 and 26 show the vasomotor responses in this case. Note the normal responses of the control fingers and the excellent response of the index finger, which was, clinically, anesthetic and analgesic. A large proportion of

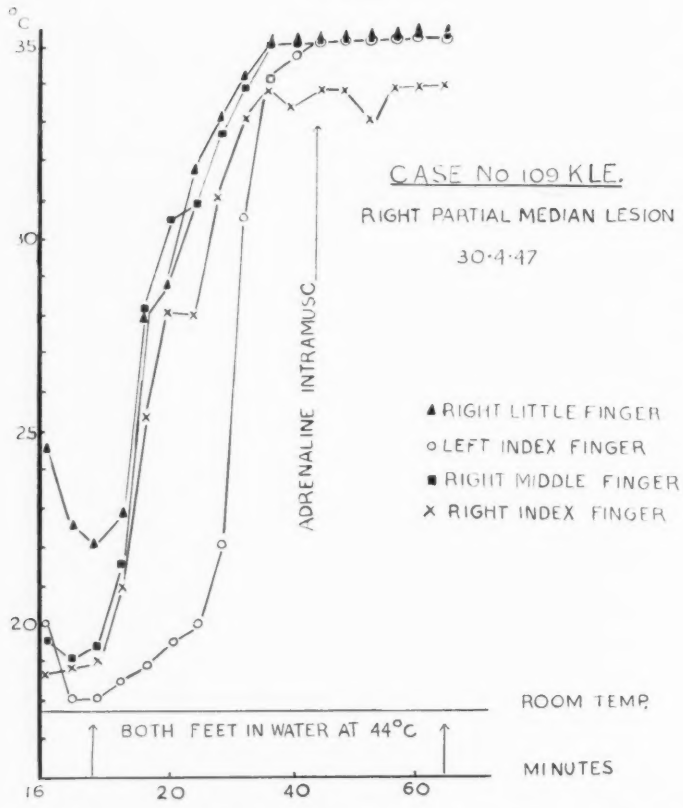

Fig. 25 (Case KLE).—Same case as in Fig. 24; vasomotor responses illustrated. (See text.)

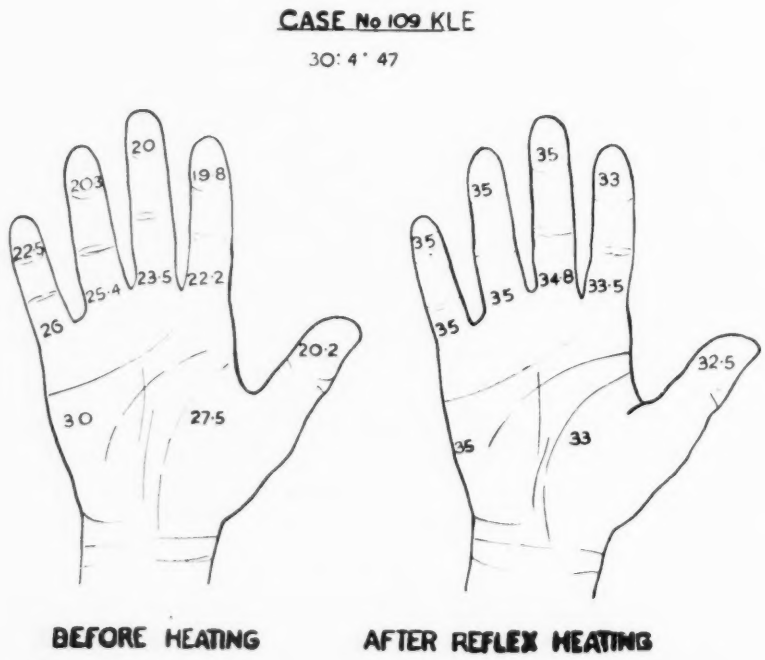

Fig. 26 (Case KLE).—Same case as in Figs. 23 and 24. Note the rise of temperature in thumb and index after reflex heating, but not up to full vasodilatation levels.

the vasomotor fibers appear to have been intact. Sudomotor tests by the quinalizarin method showed the presence of numerous pin points of sweating on the anesthetic finger, indicating the presence of sympathetic fibers.

Fig. 27 shows the vasomotor responses in a patient (Case NAG) who had a right total ulnar neurotmesis, with a partial median axonotmesis. Note absence of response in ulnar autonomous zone, and good response in median autonomous zone.

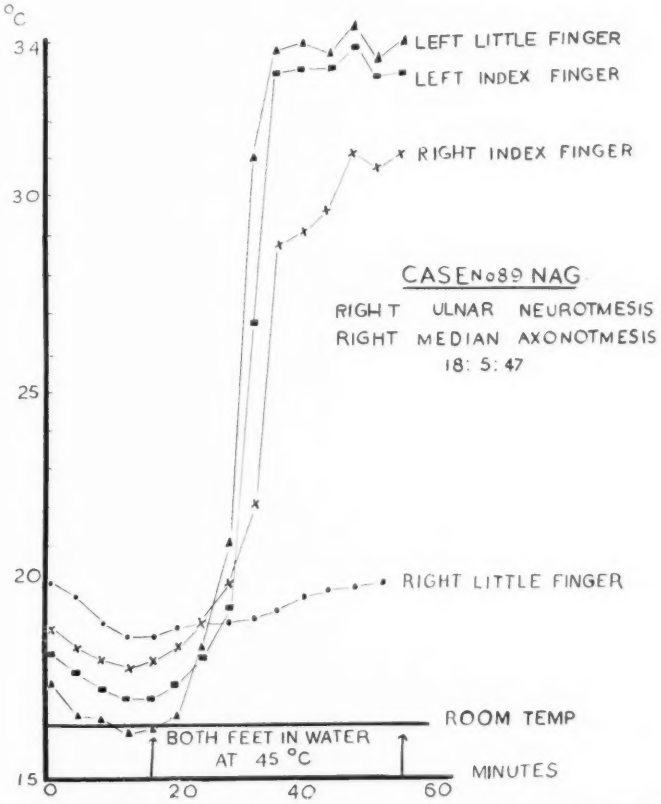

Fig. 27 (Case NAG).—Right complete ulnar and partial median lesion; vasomotor responses illustrated.

VASOMOTOR ACTIVITY DURING RECOVERY

Regeneration of a peripheral nerve following nerve suture, or following spontaneous recovery, for example, in axonotmesis, involves regeneration of motor, sensory, and sympathetic fibers. Sympathetic regeneration is demonstrable by return of sudomotor function but also by return of vasomotor activity. Such response is at first slight, of course, but becomes more marked as regeneration proceeds.

Fig. 28 shows vasomotor responses in Case JAA, five years after ulnar and median nerve suture at the elbow. Note the well-marked vasocontrictor response in the cold room, and the vasodilatation on reflex warming.

Due to great difficulty in follow-up of patients in South Africa, it has not been possible to do serial vasomotor examinations in a single case to trace the

rate and nature of returning vasomotor activity. Fig. 29 shows the vasomotor responses in Case WEL, in whom the right median nerve was sutured ten months previously. Note the normal responses in the normal control fingers, and the slow and gradual rise in temperature of the affected digit. At this time the sensory recovery was of the early type, where deep cutaneous pain sensation consisted of the diffuse, unpleasant pain with "over-response."

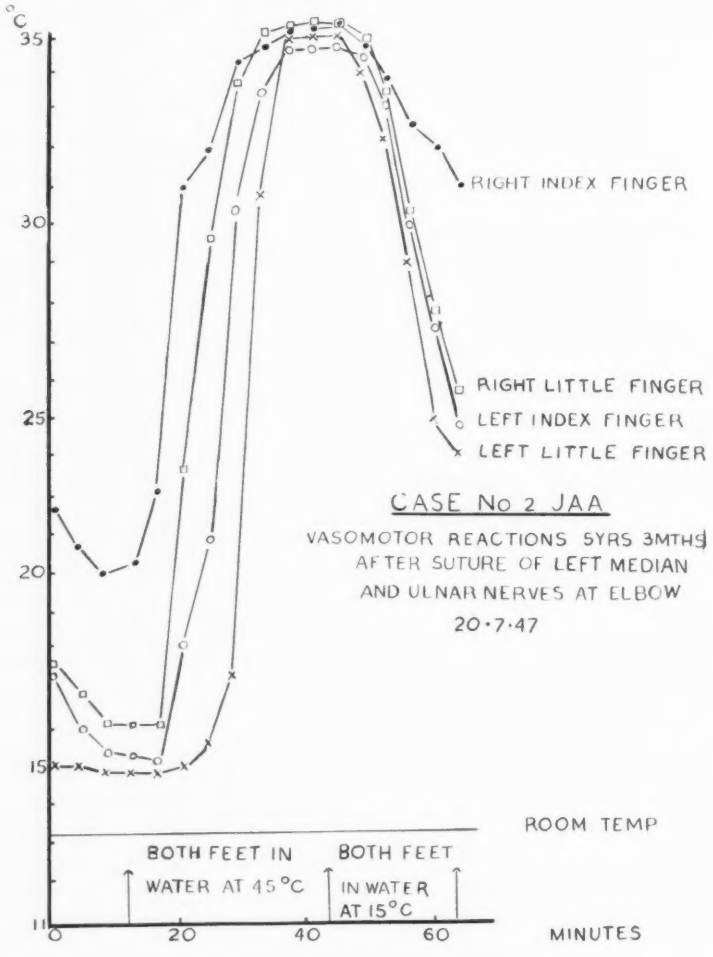

Fig. 28 (Case JAA).—Showing excellent vasomotor responses five years after suture of ulnar and median nerves of the elbow.

Case ASW is a further example of return of vasomotor function. This patient received a cut of the right median nerve at the wrist on April 5, 1943. A primary suture was performed. When examined on Feb. 8, 1946, there was poor recovery of sensation, and no recovery in the thenar muscles. He stated that his hand warms and cools slowly with changes in temperature. Plethysmography, however, indicated a good return of vasomotor function (Fig. 30).

Fig. 31 indicates slight increase in pulse volume of the left little finger after reflex warming in Case SPE eighteen months after primary suture of the left

median and ulnar nerves in the forearm. This should be compared with Fig. 32, showing reactions of normal right little finger. (There were similar findings for the index fingers.)

These cases may be considered typical of the group of recovering lesions, from the earliest signs of recovery, as in Case WEL (Fig. 29), to the full recovery of vasomotor responses after complete regeneration, as in Case JAA (Fig. 28).

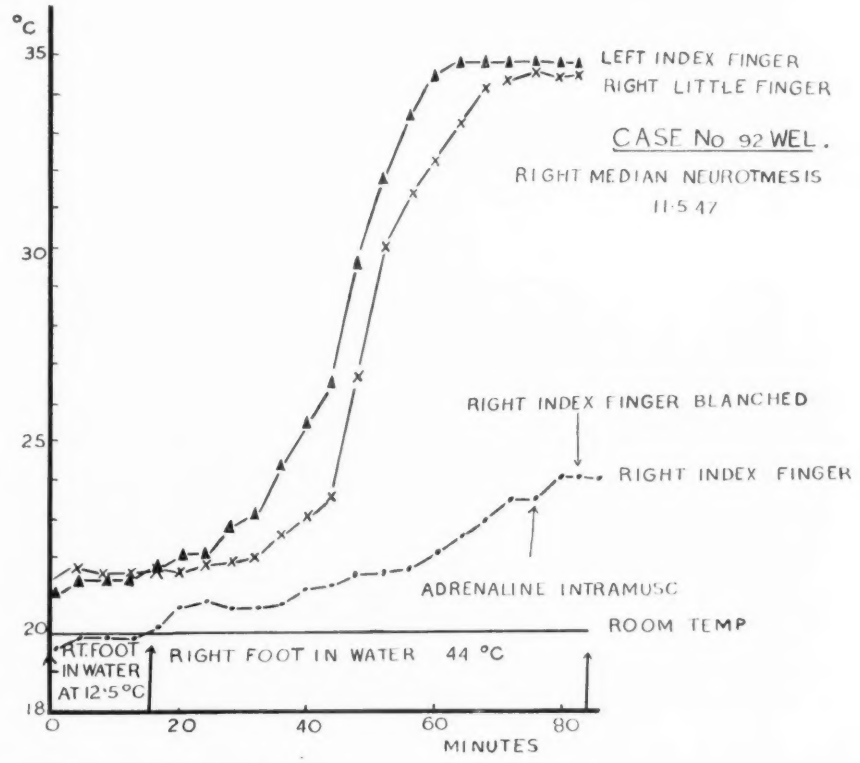

Fig. 29 (Case WEL).—Right total median nerve lesion; vasomotor responses ten months after suture in lower forearm.

DISCUSSION

After division of a peripheral nerve, the vasomotor state of the skin (and presumably the other vessels in the denervated area) passes through two phases, the initial warm phase of vasodilatation, due to the interruption of the vasoconstrictor sympathetic fibers, followed by the second, permanent cold phase, in which the temperature of the denervated skin approximates that of the surrounding environment. The time of transition between the warm and cold phases varies in different individuals.

The factors responsible for the change from warm to cold phase are not clearly understood, but certain causative agents may be discussed:

Lowering of Local Metabolism.—Lowering of local metabolism is akin to, but not the same as, disuse. Metabolic needs of inactive or inert tissues are necessarily lessened, and consequently less heat will be generated.

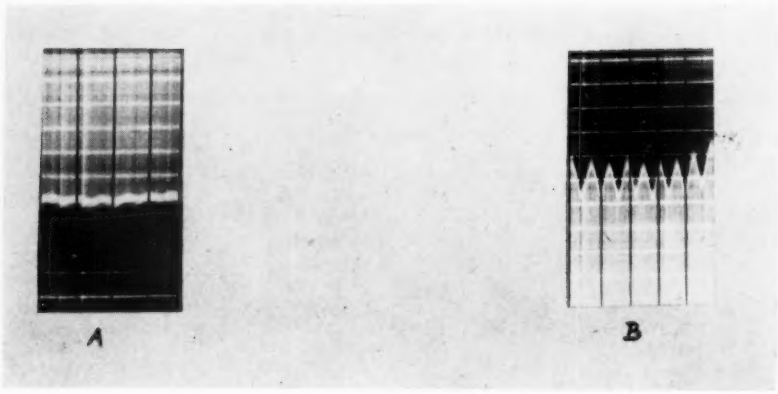

Fig. 30 (Case ASW).—Plethysmogram of right index finger three years after primary suture of median nerve. *A*, Before reflex warming; *B*, after reflex warming. Note increase in pulse volume in *B*.

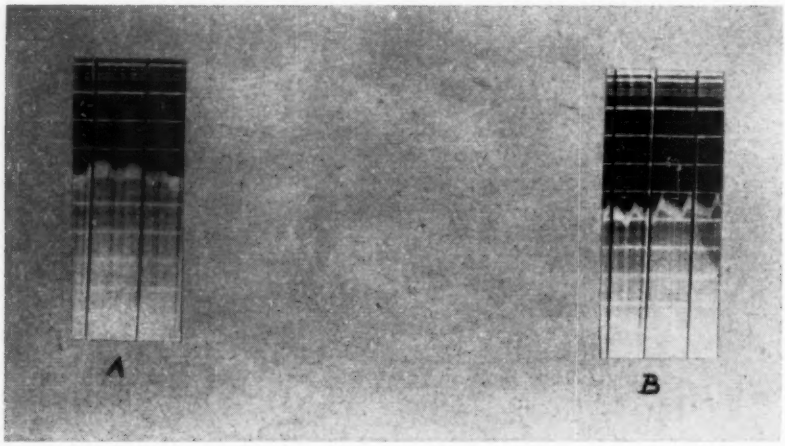

Fig. 31 (Case SPE).—Plethysmogram of left little finger eighteen months after primary suture of ulnar and median nerves in the forearm. *A*, Before reflex warming; *B*, after reflex warming. Note slight increase in pulse volume in *B*.

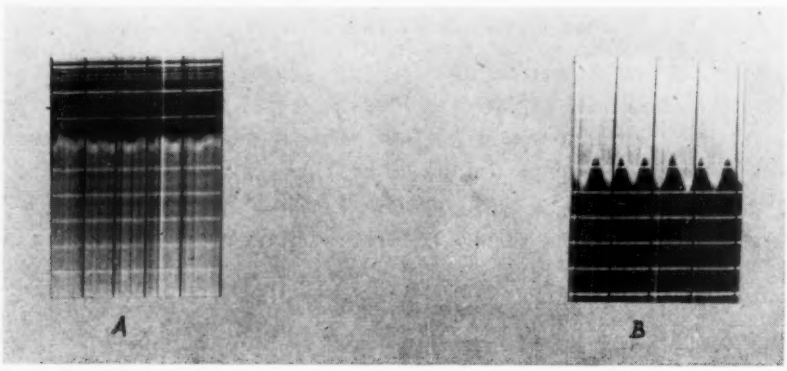

Fig. 32 (Case SPE).—Plethysmogram of *normal* right little finger. *A*, Before and *B*, after reflex warming.

Sensitization of Denervated Vessels to Circulating Adrenalin.—That denervated vessels are more sensitive to circulating adrenalin than normal vessels has been determined in cases of sympathectomy and cases of peripheral nerve division, as shown in the cases reported in this paper.

It has for many years been held that the vessels of a limb subjected to postganglionic sympathectomy are more sensitive to circulating adrenalin than those subjected to pregnanglionic sympathectomy.[13, 14] This was given as the main reason why preganglionic sympathectomy gave better results in Raynaud's disease of the upper extremity than did stellate ganglionectomy. Division of a peripheral nerve provides interruption of the postganglionic sympathetic fibers, and the denervated vessels will then be excessively sensitive to circulating adrenalin.

An interesting controlled experiment on a human being was reported by Atlas.[7] A patient with surgical section of the median nerve was later subjected to a preganglionic sympathectomy; part of the hand contained vessels of postganglionic and part vessels of preganglionic sympathetic denervation. The "postganglionic" part was colder than the other, and, on injection of adrenalin, the temperature of the postganglionic part fell by 2.6° C., and of the "preganglionic" area by 0.1° C. This indicates an increased sensitivity of the postganglionic area to adrenalin (thus also after nerve section.)

Atlas[6] also demonstrated an appreciable fall in temperature in the denervated digit of a median nerve lesion, by injecting 0.35 c.c. of 1 per cent Neosynephrin hydrochloride into the leg. Similar findings were reported by Fatherree and Allen;[15] the first observation in man was made by Fatherree, Adson, and Allen[16] in a case of median nerve lesion, although similar observations had previously been made in animals by Ascroft,[17] Dale and Richards,[18] and Grant.[4, 5]

In the investigations made in the present series, it was found that adrenalin will cause only a slight fall in temperature of normal digits, a significant fall in totally denervated digits, and a slight, but definite, fall in partially innervated digits. In one case, in the phase of recovery following nerve suture, there was no fall of temperature, but intense blanching of the affected digit (Fig. 29); this indicated hypersensitivity of the skin capillaries to circulating adrenalin.

Loss of the Afferent Nerve Supply to the Area Involved.—The "axonal vasodilatation" of Lewis[19] occurring in response to minor trauma, etc., is undoubtedly an important contributing factor in the maintenance of temperature and nutrition of the normal skin. Axonal dilatation can still be obtained soon after nerve section ("triple response" to stroking, or histamine "flare" by intradermal injection of histamine), but it disappears when nerve degeneration is complete. The response re-appears only when regeneration occurs. Lewis maintained that this is an important factor in the transition of the warm to the cold phase, as its onset corresponds (twenty-first day) roughly to the final degeneration of the interrupted nerve fibers.

Integrity of the Innervation to the Rest of the Limb.—After nerve division, peripheral neurogenic vasoconstriction will occur in the normal parts of the limb

in response to cold. This will result in a reduction of the total blood flow of the limb and contribute to the cold stage of the denervated area. Richards[9] stated that he found that a completely denervated hand (total brachial plexus lesion) tends to remain warm. This has not been our experience, and this factor of integrity of innervation to the rest of the limb does not appear to be an important one.

Local Environmental Temperature.—It has been noted that, in the warm phase, the skin of the denervated area does not cool down on exposure to cold (Fig. 2, note cold environment of 17.2° C.). In the cold phase, however, the denervated parts rapidly assume the temperature of the environment, and very gradually regain their former temperature on removal of the cold. This change is due to a local effect on the walls of the vessels. Patients will always state that, in cold weather, the hand becomes blue and cold, and feels cold to the touch for a very long time, even after warming in bed. Protecting the part by wearing a glove prevents this reaction, and this advice is usually given to a patient in the winter.

Organic Change in the Peripheral Vessels.—A factor to be considered is whether one may not get actual organic change in the peripheral vessels. This question is difficult to settle, and needs further investigation by way of examination of vessels in amputated limbs or by vessel biopsies.

Stopford[20] described a case where definite intimal thickening took place after sciatic nerve injury. Lewis and Pickering[21] showed that pulsaton in the vessels of denervated digits was only slightly reduced in volume.

I have found definite organic changes in the digital vessels of cases of complete brachial plexus lesion which came to amputation. There was definite thickening of the intima and the media, with interruption of the internal elastic lamina.

SUMMARY

The vasomotor reactions in peripheral nerve injuries have been studied.

After division of a peripheral nerve, the skin of the area supplied goes through a warm phase of vasodilatation, and passes into a cold phase after approximately twenty-one days.

The factors responsible for the transition from the warm to the cold phase are:

1. Lowering of local metabolism.
2. Sensitization of denervated vessels to circulating adrenalin.
3. Loss of the afferent nerve supply to the area involved.
4. Integrity of innervation to the rest of the limb.
5. Changes in local environmental temperature.
6. Organic changes in the peripheral vessels.

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THE IMPORTANCE OF EXPLORATORY THORACOTOMY IN THE DIAGNOSIS OF CERTAIN PULMONARY LESIONS

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THE progress that has been made in the diagnosis and treatment of serious pulmonary disorders in the last ten years has been most gratifying. New methods of diagnosis have been placed at our disposal and older methods have been improved. Chemotherapy, antibiotic therapy, and developments in thoracic surgery have provided, for most of the serious diseases affecting the lungs, therapeutic measures which are effective provided they are carried out at an opportune time. Further improvement in the results of treatment of pulmonary lesions requires earlier and wider use of the methods of diagnosis and treatment that are available. Our experience with thoracic disease in recent years has convinced us that exploratory thoracotomy carried out as a diagnostic measure is a valuable and important procedure that is not appreciated generally but which can contribute greatly to improvement in results of treatment of pulmonary disease. In support of this conviction we have recently reviewed the records of 384 patients operated upon by one of us (O. T. C.) during the period Jan. 1, 1942, to April 7, 1947, for lesions involving primarily the lungs. On the basis of the clinical records, laboratory findings, and other diagnostic aids short of exploratory thoracotomy, a diagnosis could be made in 270 of these patients (Table I). In the remaining 114, or approximately 30 per cent, of the 384 patients operated upon it was necessary to resort to exploratory thoracotomy before a definite diagnosis could be established. A study of this group of 114 indeterminate pulmonary lesions forms the basis for this report. The diagnosis in three of these cases remained indeterminate even after exploratory thoracotomy. There were then 111 cases for study.

Before entering upon a discussion of these cases, it is pertinent to review briefly the examinations and diagnostic methods that were used in our attempts to establish a definite diagnosis in these cases before resorting to exploratory thoracotomy. A complete history was obtained from each patient; this included not only a careful chronologic review of pulmonary symptoms but also the family history, history of past illness, occupations, and travels, and a review of any symptoms referable to any other organic system. A thorough physical examination was performed routinely with particular emphasis on the chest findings. Blood, urine, and serologic examinations were carried out in every case. Stereoscopic roentgenograms of the thorax were made in every case and in many cases further roentgenologic examinations were made. These included roentgenograms in the posteroanterior, lateral, and oblique projections using the

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TABLE I. PULMONARY LESIONS IN WHICH A DIAGNOSIS WAS MADE ON THE BASIS OF THE CLINICAL RECORDS, LABORATORY FINDINGS, AND DIAGNOSTIC AIDS SHORT OF EXPLORATORY THORACOTOMY (270 CASES)

	CASES
Bronchiogenic carcinoma	
Diagnosis from histologic study of tissue removed bronchoscopically	54
Diagnosis from histologic study of tissue removed bronchoscopically and by cytologic study of sputum or bronchial aspirations	6
Diagnosis by cytologic study of sputum or bronchial aspirations	3
Bronchial adenoma	
Diagnosis from histologic study of tissue removed bronchoscopically	14
Bronchiectasis	136
Tuberculosis	19
Chronic pulmonary abscess	13
Pulmonary cystic disease	17
Miscellaneous	8

Potter-Bucky diaphragm, roentgenograms made with so-called "body section" technique, and roentgenoscopic observations. Bronchograms obtained after filling the bronchial tree with radiopaque oil were used frequently. Bronchograms were most useful in the diagnosis of bronchiectasis but also gave valuable information in other cases, particularly in demonstrating obstructive lesions in bronchi not accessible to bronchoscopic examination. Most of the patients were given the benefit of bronchoscopic study of the trachea and bronchi. This examination ranks second only to roentgenologic studies in the diagnosis of pulmonary disease. It not only provides accurate diagnosis of the location and extent of disease in many instances but also permits removal of tissue for pathologic examination. In an occasional case it was obvious that the lesion was in a portion of the lung inaccessible to bronchoscopic examination and this procedure was omitted. Tuberculin skin tests were carried out in most cases. Whenever obtainable, sputum was examined for acid-fast organisms and fungi. Sputum cultures, cultures of gastric aspirations, and guinea pig inoculations were carried out whenever indicated.

Examination for malignant cells, of sputum, and of bronchial secretions obtained at bronchoscopy was not carried out extensively in this series. However, this method has recently proved to be one of the most valuable aids available for the diagnosis of bronchiogenic carcinoma, particularly for those lesions not accessible for bronchoscopic examination and biopsy. During the last year a positive diagnosis of bronchiogenic carcinoma has been made from microscopic examination of sputum and bronchial secretion in 160 instances. We are confident that if this method had been available most of the cases of carcinoma found in the group of cases we are reporting could have been diagnosed accurately preoperatively. The technique requires a highly skilled and experienced pathologist but its value cannot be questioned. The development of this method of diagnosing bronchiogenic carcinoma is the most outstanding contribution to thoracic diagnosis in many years. Today a center for the diagnosis of thoracic disease cannot be considered complete unless it has a pathologist competent to carry out this examination.

ANALYSIS OF CASES

On the basis chiefly of the bronchoscopic and roentgenographic findings the 111 cases which form the basis for this study were divided into three groups.

Group 1 included all cases in which the predominant roentgenologic finding was the presence of a mass lesion in the lung usually located in a portion of the lung peripheral to the field of bronchoscopic visualization. Group 2 included those cases in which the lesion was represented primarily by changes secondary to bronchial obstruction. A small group of cases presented lesions which could not be placed satisfactorily in either of the first two groups and these cases were accordingly placed in Group 3, a miscellaneous group. The final diagnoses obtained from pathologic examination of tissue removed at the time of operation are given for the three groups in Table II.

TABLE II. INDETERMINATE LESIONS: FINAL DIAGNOSIS AS DETERMINED AT THORACOTOMY (111 CASES)

DIAGNOSIS	MASS LESIONS	LESIONS PRODUCING BRONCHIAL OBSTRUCTION	MISCELLANEOUS
Neoplastic			
Malignant			
Bronchiogenic carcinoma	35	23	2
Lymphosarcoma		1	
Fibrosarcoma	1		
Metastatic			
Osteogenic sarcoma	1		
Adenocarcinoma	2		
Benign			
Bronchial adenoma	2	1	3
Hamartoma	2		
Teratoma	1		
Endobronchial lipoma		1	
Diffuse adenomatosis		1	
Tumor-forming amyloid*		2	
Inflammatory			
Chronic pneumonitis			
Suppurative with abscess	2	8	3
Lipoid	1	1	1
Secondary to broncholithiasis		2	
Secondary to silicotic stricture			1
Miscellaneous		5	
Tuberculosis	3	1	
Mycoses			
Actinomycosis		1	
Coccidioidomycosis	2		
Developmental			
Bronchial cyst	1	1	
Total	53	48	10

*Not a neoplasm—included here for reason of convenience.

Mass Lesions.—Group 1, consisting of patients with mass lesions, made up the largest number of indeterminate pulmonary lesions for which exploratory thoracotomy was performed. Roentgenologically, 90 per cent of the lesions appeared to be located in the peripheral portions of the pulmonary field. The remainder were more centrally located but were still beyond the field of bronchoscopic visualization and biopsy. Slightly more than one-half of the lesions were in the upper lobes. Changes secondary to bronchial obstruction appeared in association with five of the mass lesions. In all the cases in this group, however, the presence of the mass was the predominant finding. In three instances cavitation within the mass was demonstrated (Fig. 1). In each of these three cases the lesion proved to be bronchiogenic carcinoma.

After a thorough study of the roentgenograms in these cases in which mass lesions presented, it was apparent that no definite criteria could be found to distinguish one type of lesion from another. In fact, a striking similarity was noted in the roentgenographic appearance of various types of benign and malignant lesions. In general, the benign lesions tended to be more sharply circumscribed; however, there were notable exceptions (Figs. 2 and 3).

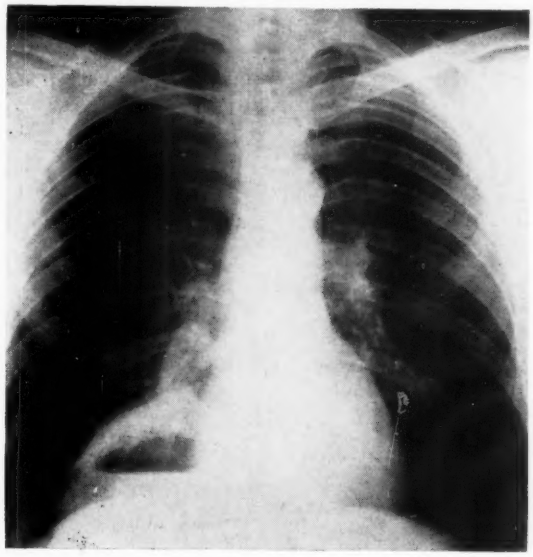

Fig. 1.—Mass lesion, bronchiogenic carcinoma; note cavitation and fluid level within mass.

A correlation of the roentgenographic findings with the clinical symptoms and bronchoscopic findings provided, at most, no more than an impression as to whether the lesion was benign or malignant (Tables III and IV). It is highly significant that thirty-nine, or 74 per cent, of the fifty-three mass lesions were proved at operation to be malignant. Our conviction that indeterminate mass lesions in the lung deserve exploratory thoracotomy without delay is supported by this evidence. It is significant that the other lesions discovered by exploratory thoracotomy in this group proved, in the great majority of instances, to be lesions which could be treated most effectively by surgical means. They included three tuberculomas, two adenomas, two pulmonary abscesses, three hamartomas, one of coccidioidomycosis, and three metastatic tumors.

Lesions Producing Bronchial Obstruction.—There were some symptoms of pulmonary diseases in all the patients who presented lesions that produced bronchial obstruction. The symptoms are indicated in Table V. Recurring episodes of cough, fever, thoracic pain, and expectoration of purulent and sometimes bloody sputum characterized the history of this group of patients with bronchial obstruction regardless of the cause of the obstruction. Roentgenologic examinations demonstrated the presence of some degree of atelectasis in more than one-half of this group of cases. In the remainder the lesion was described variously by the roentgenologist as that of an inflammatory, infiltrative, cavitat-

ing, or consolidative process in the lung. In each instance the presence of bronchial obstruction was established by bronchoscopic, tomographic, or bronchographic means (Figs. 4, 5, and 6).

At bronchoscopy an obstructing lesion was visualized which proved to be benign in four cases and that of bronchiogenic carcinoma in five cases (Table VI). It is of interest to report that in two instances of chronic pulmonary abscess and in one of chronic lipoid pneumonitis the obstructing lesion had the bronchoscopic appearance of a carcinoma. In one case of chronic pneumonitis with bronchiectasis the bronchoscopic appearance of the obstruction suggested that the lesion was an adenoma of the bronchus. Tissue removed from these lesions as

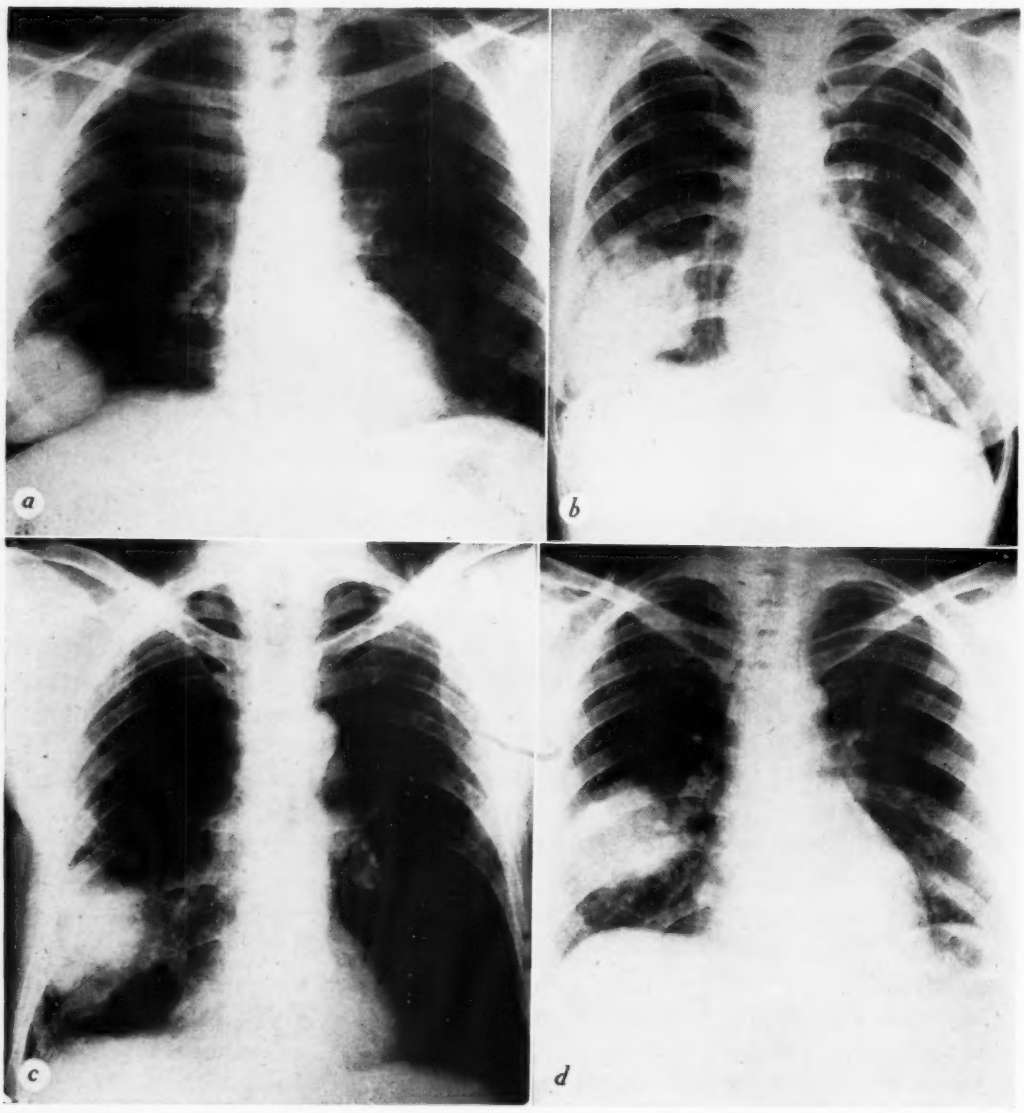

Fig. 2.—Mass lesions. *a*, Fibrosarcoma; *b*, tuberculoma; *c*, chronic abscess; *d*, bronchiogenic carcinoma.

well as that removed from the lesions of the five patients who were proved at operation to have carcinoma was all reported by the pathologist as inflammatory tissue. Tissue and scrapings from areas of granulation and the stenosed bronchus were reported as inflammatory in all cases.

The presence of an underlying malignant growth was found at operation in twenty-four, or 50 per cent, of the forty-eight cases in which the bronchoscopic and roentgenographic evidence of disease was only that of bronchial obstruction (Table II). The presence of a malignant tumor had, of course, been suspected in many of these cases. Nevertheless, it had been impossible to make a positive

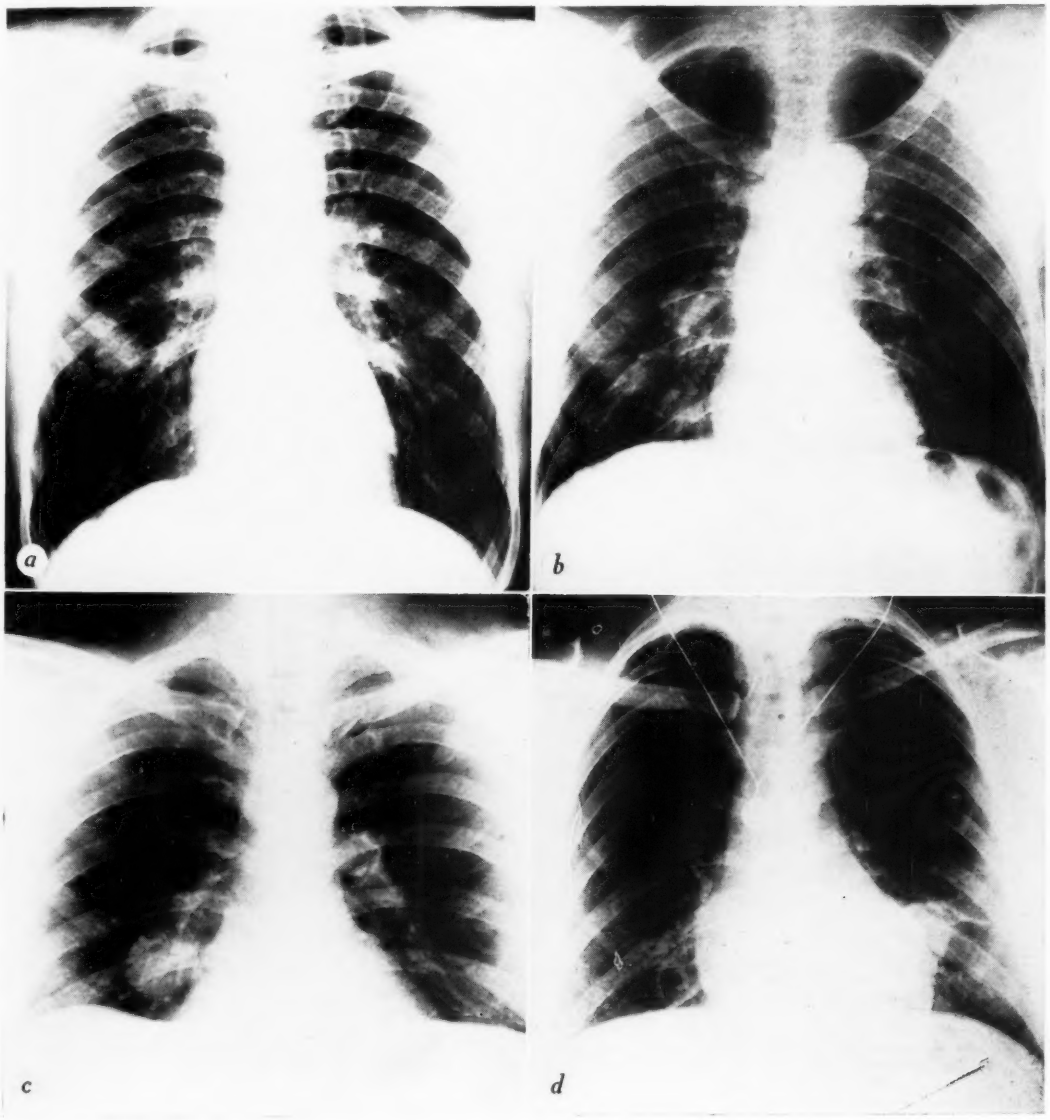

Fig. 3.—Mass lesions. *a*, Bronchiogenic carcinoma; *b*, hamartoma; *c*, bronchial adenoma; *d*, nodular type of coccidioidomycosis.

diagnosis preoperatively and the indication for operation was the presence of an obstruction of the bronchus not remediable by conservative measures owing to the presence of irreversible pulmonary changes including various degrees of fibrosis, bronchiectasis, and suppuration.

There were two cases of tumor-forming amyloid observed in this group. These cases have been reported elsewhere.[1]

Amyloid deposits have been reported as occurring in the respiratory tract, chiefly in the larynx, as tumors or as diffuse subepithelial infiltrates.[2, 3, 4] A diagnosis can be made by histologic examination if the lesion is accessible for biopsy.

TABLE III. MASS LESIONS: SYMPTOMS IN ORDER OF FREQUENCY OF OCCURRENCE (53 CASES)

MALIGNANT (39 CASES)		BENIGN (14 CASES)	
SYMPTOM	INCIDENCE	SYMPTOM	INCIDENCE
No symptoms	6	No symptoms	4
Cough	23	Pain	6
Pain	18	Fever	5
Weight loss	16	Cough	3
Hemoptysis	13	Fatigue	3
Fever	8	Weight loss	3
Sputum	6	Dyspnea	2
Fatigue	6	Hemoptysis	2
Dyspnea	4	Sputum	1
Wheeze	3		

TABLE IV. MASS LESIONS: BRONCHOSCOPIC FINDINGS (53 CASES)

FINDING	MALIGNANT (39 CASES)	BENIGN (14 CASES)
Distortion of tracheobronchial tree	8	1
Area of infiltration	4	1
Purulent secretion from bronchus	3	2
Bloody secretion from bronchus	3	1
Negative	15	6
Bronchoscopic study not done because lesion situated too far peripherally	6	3

TABLE V. LESIONS REPRESENTED PRIMARILY BY CHANGES SECONDARY TO BRONCHIAL OBSTRUCTION: SYMPTOMS IN ORDER OF FREQUENCY OF OCCURRENCE (48 CASES)

MALIGNANT (24 CASES)		BENIGN (24 CASES)	
SYMPTOM	INCIDENCE	SYMPTOM	INCIDENCE
Cough	22	Cough	20
Sputum	19	Sputum	20
Weight loss	16	Fever	16
Fever	13	Pain	14
Pain	12	Weight loss	12
Hemoptysis	7	Hemoptysis	10

TABLE VI. LESIONS REPRESENTED PRIMARILY BY CHANGES SECONDARY TO BRONCHIAL OBSTRUCTION: BRONCHOSCOPIC FINDINGS (48 CASES)

FINDING	MALIGNANT (24 CASES)	BENIGN (24 CASES)
Distortion of tracheobronchial tree	2	0
Obstructing lesion	5	4
Presence of granulations	4	2
Narrowing or stenosis of bronchus	3	3
Purulent secretions from bronchus	2	6
Bloody secretions from bronchus	3	3
Negative	5	6

The amyloid in these instances, however, does not take on the walnut or mahogany brown color when stained with iodine as does the type which may occur in association with long-standing suppurative disease such as chronic osteomyelitis; presumably the basis of the difference is the chemical nature of the two types of amyloid. Tumor-forming amyloid is not a progressive disease. A procedure sufficient for its complete removal is all that is indicated.

Miscellaneous Group.—This group of ten cases includes those instances in which a mass lesion could not be visualized roentgenographically and in which

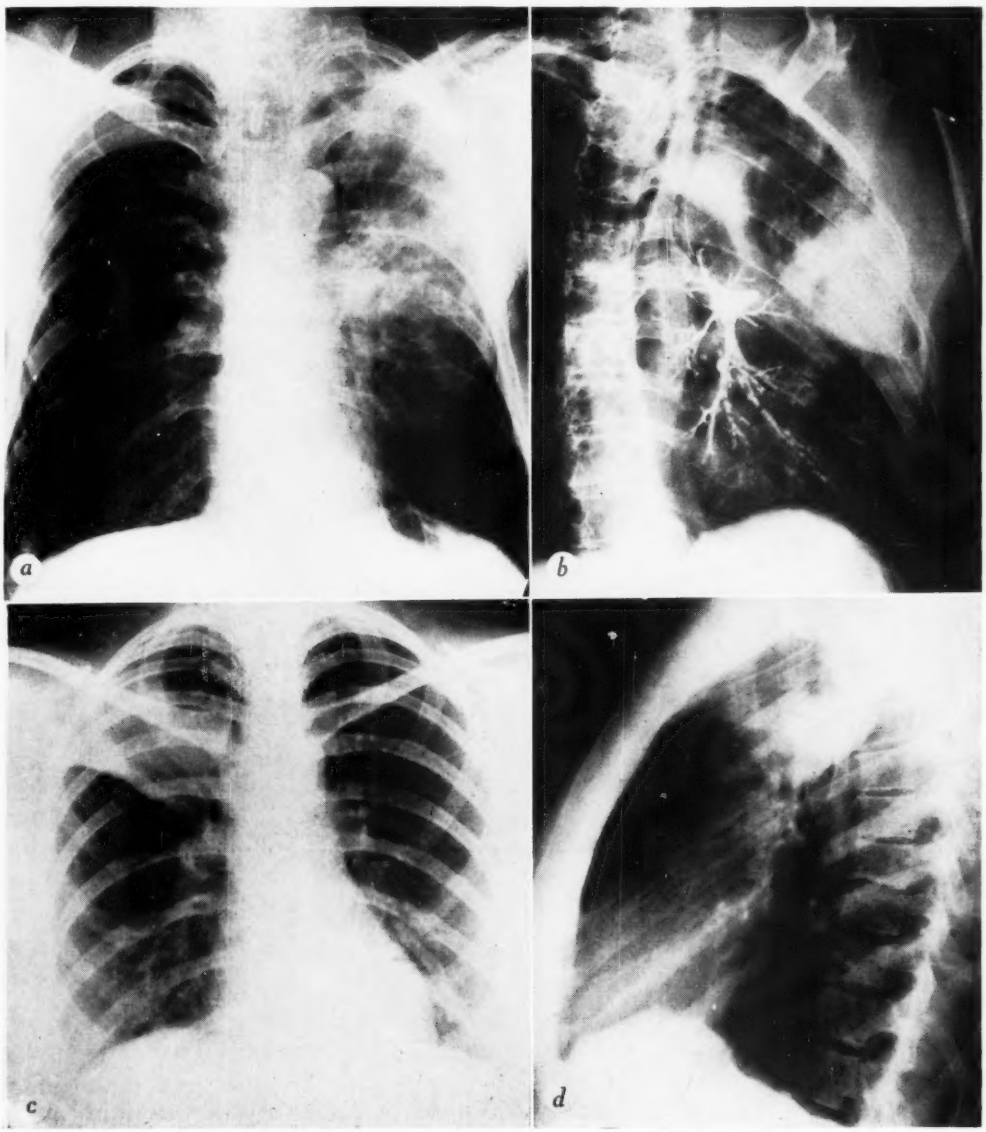

Fig. 4.—Lesions represented primarily by changes secondary to bronchial obstruction. *a*, Bronchiogenic carcinoma; note atelectasis of right middle lobe. *b*, Same case as in *a*; lateral gram showing complete obstruction of left upper lobe bronchus proximal to its bifurcation. *c*, Lipoid pneumonitis with stricture of right upper lobe bronchus; note partial atelectasis of right upper lobe. *d*, Same case as in *c*; lateral view.

definite obstruction of a bronchus could not be demonstrated preoperatively. The question usually arose in these cases as to whether one was dealing with a tuberculous lesion, a nonspecific inflammatory process which would subside, a neoplasm, or irreversible inflammatory changes in the lung that were of nonspecific origin. Some of these patients were observed over a period of weeks, and changes in the roentgenographic picture were noted before surgical intervention was advised. The findings at operation justified exploration even in this group in which the preoperative diagnosis was most indefinite. In two cases the lesion proved to be carcinoma; in three, bronchial adenoma; in three, suppuration and abscess; in one, lipoid pneumonitis, and in one, a silicotic stricture of the bronchus. All were lesions which could be treated most effectively only by pulmonary resection.

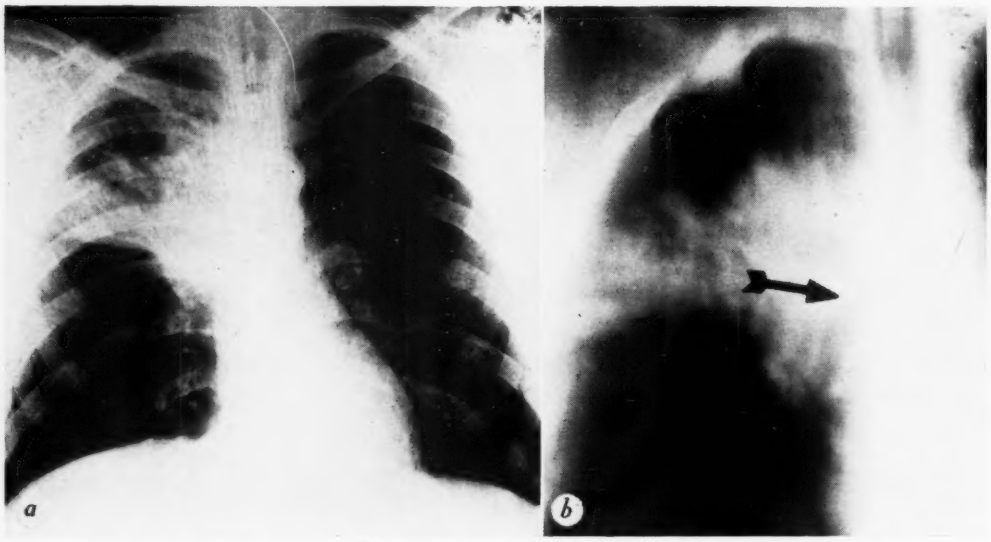

Fig. 5.—Lesion represented primarily by changes secondary to bronchial obstruction. *a*, bronchiogenic carcinoma of right upper lobe with partial atelectasis; *b*, same case as in *a*, tomogram showing complete obstruction of right upper lobe bronchus near its origin.

DISCUSSION

It is obvious that if the patients whose lesions were represented primarily by changes secondary to bronchial obstruction (Group 2) had been seen earlier, some would have presented mass lesions (Group 1). This would certainly be true of many with bronchiogenic carcinoma. The time at which the effects of an obstructing lesion in a bronchus become evident depends, of course, upon the location and character of the lesion. Eleven, or 28 per cent, of the thirty-nine malignant lesions in Group 1 were found inoperable, whereas eleven, or 46 per cent, of the twenty-four malignant lesions included in Group 2 were inoperable.

It is not presumed that an obstruction to a bronchus was the primary initiating factor in the pathogenesis of all the lesions in Group 2. It is difficult to imagine a pulmonary lesion of any magnitude not associated with obstruction of at least smaller bronchi. When an obstruction to a bronchus is definitely demonstrated, however, its presence is an accentuating and perpetuating factor

in the disease process. This consideration is of paramount importance in evaluating the need for surgical therapy.

Correlation of Diagnostic Procedures.—The roentgenogram of the thorax remains as the most important single procedure for apprehending the presence of a pulmonary lesion; however, it cannot be too strongly emphasized that the roentgenogram is not a means of exact diagnosis. If the presence of a serious lesion can be suggested by roentgenography, then the maximal benefit to the patient from this procedure will have been realized. Other procedures can then be carried out in proper sequence for the establishment of the final diagnosis.

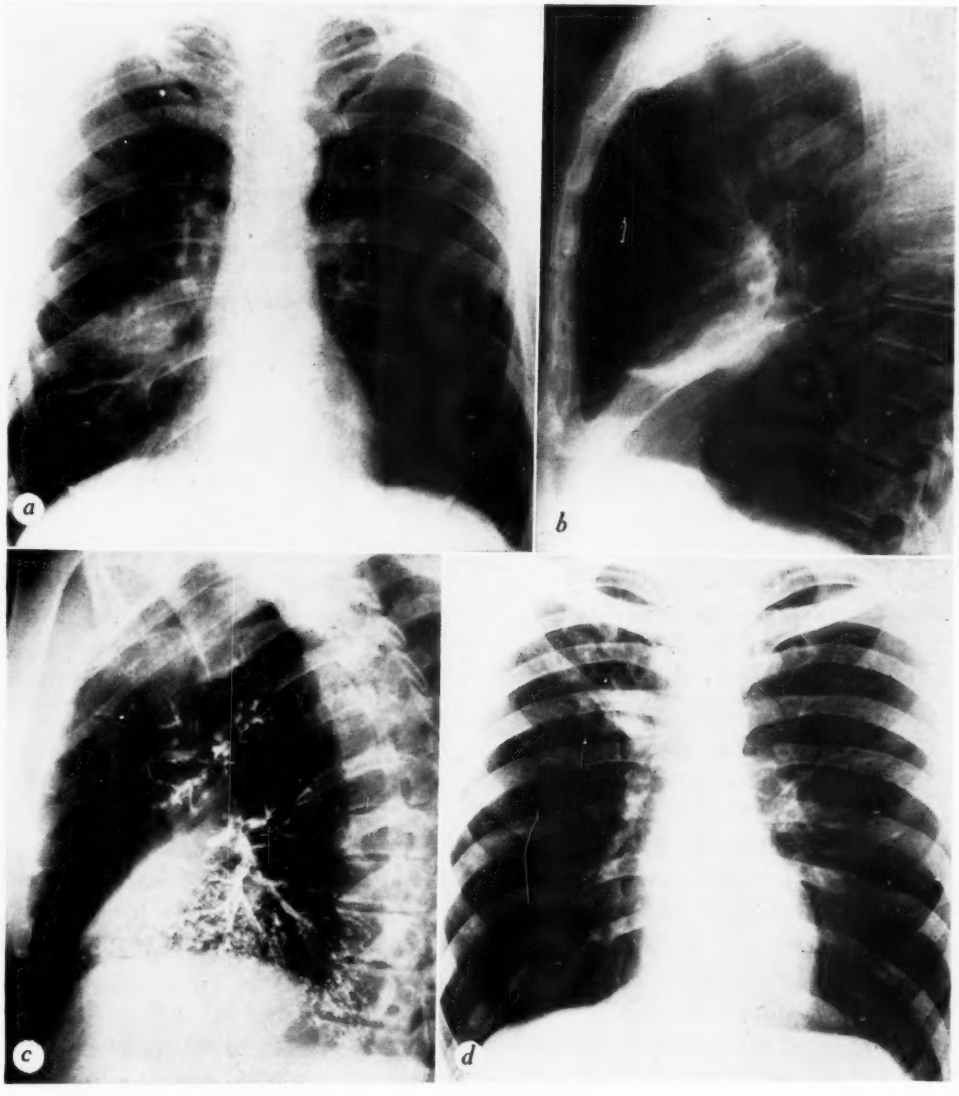

Fig. 6.—Lesions represented primarily by changes secondary to bronchial obstruction. *a*, Bronchiogenic carcinoma; note atelectasis of right middle lobe. *b*, Same case as in *a*; lateral view. *c*, Same case as in *a*; bronchogram showing complete obstruction of middle lobe bronchus. *d*, Bronchiogenic carcinoma; lesion simulates tuberculous infiltration; obstruction to right upper lobe bronchus was established bronchoscopically.

It is appropriate at this time to mention too that a bronchiogenic carcinoma occasionally may be demonstrated in spite of a normal roentgenogram. The lesions of two other important diseases may be present without producing abnormal densities in the roentgenogram; these are bronchiectasis and bronchial adenoma. If the plain film is studied carefully, evidence of bronchiectasis will be present in more than 90 per cent of cases.[4] Substantiation of the presence of this disease remains for bronchographic study. The final diagnosis in cases of bronchial adenoma is established by bronchoscopy in the majority of instances, by exploratory thoracotomy in the remainder.

By referring to Tables I and II it will be seen that in the 123 patients with bronchiogenic carcinoma who were operated upon by one of us (O. T. C.), the final diagnosis was established by the histologic study of tissue removed bronchoscopically in sixty, by exploratory thoracotomy in sixty, and by the cytologic study of sputum or bronchial secretions in three. Cytologic study was carried out in 21 of the 123 patients. The presence of malignant cells was reported in nine; in twelve the results were negative. In six of the nine cases in which the presence of malignant cells was reported the diagnosis also was made from a study of tissue removed bronchoscopically.

The present status of the diagnosis of bronchiogenic carcinoma by cytologic study in the Mayo Clinic cannot be assessed from the present study. The time interval covered by this report included only that period when this important diagnostic procedure was being instituted and standardized. A relatively greater number of lesions are being diagnosed by this method at the present time. This will become even more apparent in the future. As mentioned previously, 160 positive sputum examinations for bronchiogenic carcinoma have now been reported at the clinic. Herbut and Clerf[5] have reported that in thirty consecutive cases of primary pulmonary carcinoma, cancer cells were demonstrated in twenty-two cases, or 73 per cent, by means of the cytologic study of bronchial secretions stained by the Papanicolaou technique. In the same series a positive morphologic diagnosis from a study of tissue removed endoscopically was reported in eleven cases, or 37 per cent. Cells were present in the secretions in seven cases in which bronchoscopy gave negative results.

A period of observation must be classed as a diagnostic aid and has its place in the sequence of diagnostic events. Only too often, however, it is used immediately after the presence of a minimal abnormality has been demonstrated in the roentgenogram. This "wait and see" policy represents one of the major pitfalls in the establishment of an earlier diagnosis in serious pulmonary disease. In the type of indeterminate lesion included in Group 3, in which a mass could not be demonstrated and in which no obstruction to a bronchus was found to account for the persistence of pulmonary changes, a period of observation was the deciding issue in determining the need for exploration in some cases. This period should not be longer than four weeks. A simple inflammatory process would be expected to subside within this period. A period longer than this may spell failure in dealing with a bronchiogenic carcinoma.

In this group of indeterminate lesions it was impossible in some cases to determine by means of inspection and palpation alone whether we were dealing with a benign or a malignant lesion. In such instances it was usually possible

to perform a segmental excision or a lobectomy as an initial procedure since the majority of these lesions were situated peripherally. Further operative procedure depended upon the pathologist's report and upon the physiologic integrity of the remaining pulmonary tissue.

Segmental excision or lobectomy was the procedure employed for all benign lesions when it was technically possible. Lobectomy was the operation of choice in a few selected cases of bronchiogenic carcinoma. These included patients of advanced age with limited pulmonary reserve, especially if palliation was the chief thing to be gained, as well as some patients in whom no nodal involvement was demonstrated. Pneumonectomy was performed in the remainder.

In 3 of the 114 cases of indeterminate lesion the diagnosis remained indeterminate after exploratory thoracotomy. These three patients were all inoperable. In two, a hard mass about the hilus was found; a biopsy of hilar nodes in one of these did not reveal the presence of cancer and it was unsafe to perform biopsy on the other lesion. In the third patient, a hard invasive lesion extending from the hilus to the diaphragm with involvement of the esophagus was found. Several biopsy specimens were reported as inflammatory tissue.

Any operative procedure must be judged in the light of what it accomplishes and the mortality which it entails. There were no deaths among the twenty-five patients who underwent exploration only (Table VII). Six deaths followed pneumonectomy and two followed lobectomy. The 8 deaths in this group of 114 cases of indeterminate lesions were all on the basis of therapeutic considerations.

TABLE VII. INDETERMINATE LESIONS: OPERATIVE PROCEDURES AND HOSPITAL MORTALITY (114 CASES)

OPERATION, TYPE AND NUMBER		DEATHS	DIAGNOSES, TYPE, AND NUMBER AMONG PATIENTS WHO DIED AFTER OPERATION	
Exploration	25	0		
Pneumonectomy	44	6	Bronchogenic carcinoma	4
			Lymphosarcoma	1
			Adenoma	1
Lobectomy	41	2	Adenoma	1
			Necrotic granuloma	1
Segmental resection	3	0		
Enucleation	1	0		

SUMMARY AND CONCLUSIONS

1. The roentgenogram of the thorax is the most important single procedure for apprehending the presence of a pulmonary lesion. Inclusion of a roentgenogram of the thorax as part of the examination of all patients having pulmonary symptoms as well as those presenting themselves for a general medical examination is now within the realm of practicability. It is strongly emphasized that the roentgenogram is not a means of exact diagnosis. If the presence of a serious lesion in the lungs can be suggested by roentgenography, then the maximal benefit to the patient from this procedure will have been realized. It then remains for other procedures to be carried out as an unbroken chain of diagnostic events, terminating with exploratory thoracotomy, if necessary, for establishment of the final diagnosis.

2. From an analysis of 114 pulmonary lesions which were finally submitted to exploratory thoracotomy for establishment of a diagnosis, the indications for this procedure can be more clearly defined. On the basis of bronchoscopic and roentgenographic findings, these cases were divided into three groups which provided a practical working basis for the management of the patients. The first group included all cases in which the predominant picture was the presence of a mass lesion in the lung peripheral to the field of bronchoscopic visualization. In the second group were placed those cases in which the lesion was represented primarily by changes secondary to bronchial obstruction. A relatively small number of patients presented with lesions which could not be placed in either the first or second group and were accordingly placed in a third or miscellaneous group.

3. Seventy-four per cent of the fifty-three mass lesions were proved to be malignant. No definite gross criteria could be found which would distinguish a benign from a malignant lesion. Definite indications for the removal of the great majority of the benign lesions existed, based upon the character of these lesions. The presence, therefore, of a mass lesion of indeterminate nature is an indication for exploratory thoracotomy.

4. The presence of an underlying malignant neoplasm was demonstrated in 50 per cent of the forty-eight lesions which were represented primarily by changes secondary to bronchial obstruction. Notwithstanding this important consideration, the primary indication for thoracotomy in this group was the presence of an obstruction to a bronchus with the occurrence of irreversible pulmonary changes.

5. A comparatively small group of ten patients having lesions of indeterminate nature in whom a mass could not be visualized roentgenographically and in whom a definite obstruction to a bronchus could not be demonstrated were submitted to thoracotomy because the lesion failed to subside after a period of observation.

6. Three of the 114 indeterminate pulmonary lesions remained indeterminate after exploratory thoracotomy. Regardless of the nature of these three lesions, they were inoperable.

7. There were no deaths among the twenty-five patients who underwent exploration only. Six deaths followed pneumonectomy and two followed lobectomy. The eight deaths in this group of 114 indeterminate lesions were all on the basis of therapeutic considerations.

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EPIPHRENIC ESOPHAGEAL DIVERTICULUM ASSOCIATED WITH CARDIOSPASM

Report of Successful Diverticulogastric Anastomosis

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IN VIEW of the infrequent reports of successful treatment of epiphrenic esophageal diverticula it is probably fortunate that this is such a rare disease. Garnet[1] reported forty-nine cases in the literature up until 1933. Lahey[2] reported only four such cases observed at the Lahey Clinic up until 1940. Relief of symptoms was reported by Lahey in one patient as a result of freeing the pouch of the diverticulum from its dependent position and suturing it in an upside-down position to the posterior chest wall to avoid retention and stagnation. This same procedure, although once recommended for treating similar diverticula in the hypopharyngeal region, has now been practically abandoned in favor of resection of hypopharyngeal diverticula.

One of the primary objections to replacing an epiphrenic diverticulum in an upside-down position is its failure to correct the patient's chief symptom, which is ordinarily dysphagia, from the associated cardiospasm. This cardiospasm, advancing to a complete stenosis of the cardia from scar tissue formation in some patients observed by one of us (J. K. P), is a frequent complication apparently due to irritation from the associated diverticulitis and esophagitis. Raven[3] stated that, "The majority of the diverticula of the lower thoracic esophagus observed during life are associated with cardiospasm." Vinson[4] reported cardiospasm in eight of twenty-three patients with epiphrenic diverticula and advised repeated dilatation of the cardia by hydrostatic bags for symptomatic relief. Dessecker[5] reported two patients with epiphrenic diverticula, both of whom had cardiospasm. Three other patients with large epiphrenic diverticula observed by one of us (J. K. P.) all had marked cardiospasm. One patient had required gastrostomy feedings for five years. This cardiospasm is probably one of the causes for the extremely poor results obtained by resection of epiphrenic diverticula as Rosenak[6] reported two patients both of whom died from mediastinitis as a result of resection of epiphrenic diverticula. The only successful resection which has been found in a review of the literature was done by Barrett[7] in 1933.

The majority of authors on the subject, Holinger,[8] Wallace,[9] Rosenak,[6] and Vinson,[4] advise symptomatic treatment by esophageal gavage and dilatation of the cardiospasm by hydrostatic bags in view of the high mortality associated with resections. The anastomosis of the diverticulum to the stomach, as was

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done in this patient, was mentioned by several of these authors but dismissed as extremely hazardous without citing any examples successful or otherwise. This diverticulogastric anastomosis was first proposed by Lotheissen on the basis of experimental work on cadavers, which was reported by Dessecker in 1924. No reports on the clinical application of the esophageal diverticulogastric anastomosis have been discovered in the literature preceding the one presented here.

CASE REPORT

H. W., a 56-year-old man, first entered the Portland Veteran's Hospital with a fractured hip in December, 1938, at which time he had a negative chest examination and no symptoms referable to the gastrointestinal tract. At the time of the second admission in November, 1940, he complained of progressive difficulty in swallowing, regurgitation, and substernal pain radiating to both sides of the chest. These symptoms had begun about one year previously following a period of extreme nervousness. They were associated with periods of intense flushing, diaphoresis, and a feeling of engorgement of the jugular vein. A loss of twenty-eight pounds occurred during the year preceding this admission. A barium swallow in January, 1940, revealed a large diverticulum and several smaller ones extending from the middle third of the esophagus down to the cardia, associated with an apparent cardiospasm.

Considerable enlargement of the principal diverticulum had occurred between January and October, 1940, when the cardia was dilated to a size 51 esophageal bougie. only a moderate resistance was said to have been noted at this time in dilating the cardia, and the patient's dysphagia was thought to be due to cardiospasm secondary to diverticulitis. During this hospitalization the patient was treated with a soft diet and inadvertently swallowed some soap powder in February, 1940. Following this he complained of increasing nervousness, chest pain, and vomiting. A morphine addiction was acquired during the following nine months of treatment of these symptoms.

During the next six years the patient continued to exist on a semiliquid diet with repeated dilatations of the cardia by esophageal bougies. Ingestion of any meat or roughage caused immediate regurgitation.

At the time of the patient's fourth admission on August 16, 1946, he was seventy-one pounds under his usual weight and taking 10 gr. of morphine daily. Examination showed an emaciated, chronically ill white man of 56 years with ankle edema and bilateral râles at the bases of the lungs. An area of flatness was also present over the left lower posterior chest just above the diaphragm. Examination of the heart showed normal findings with a blood pressure of 137/70, suggesting that the edema was nutritional rather than cardiac. Laboratory data August, 1946, revealed blood normal except for hypochromic anemia, red blood count 3.5; hemoglobin, 64 per cent; Wassermann 3 plus; repeat 4 plus; electrocardiogram normal; blood urea nitrogen, 21; urine normal; total protein 4.65; albumin 2.76; globulin 1.95; ratio 1.3:1.

A barium swallow in August, 1946, showed the previously noted diverticula still present, with a marked increase in size of the major one, which could now be dilated to a 500 c.c. capacity. An almost complete stenosis or spasm of the cardia was apparently present as judged by the failure of barium to pass into the stomach.

Before any reconstructive surgery could be attempted to correct the esophageal obstruction the patient's nutritional deficiency required correction. To accomplish this a Levine tube was inserted into the stomach following an esophagoscopic dilatation of the cardia and aspiration of the contents of the diverticula beginning August 28, 1946. A 5000 calorie, high protein liquid diet was administered daily through the Levine tube with nothing by mouth for the next three months. A gradual loss of weight was noted during the first three weeks of this regime, apparently due to loss of edema fluid. During the following forty-eight days, however, the patient gained seventeen pounds and showed considerable improvement in blood protein level. A determination in November, 1946, showed total protein

5.7, albumin 3.6, globulin 2.1, and albumin-globulin ratio 2.7:2. A barium swallow in November, 1946, revealed a reduction in size of about 50 per cent in the large diverticulum since the patient had been taking nothing by mouth. A slow reduction in morphine consumption from 10 gr. daily had also been accomplished.

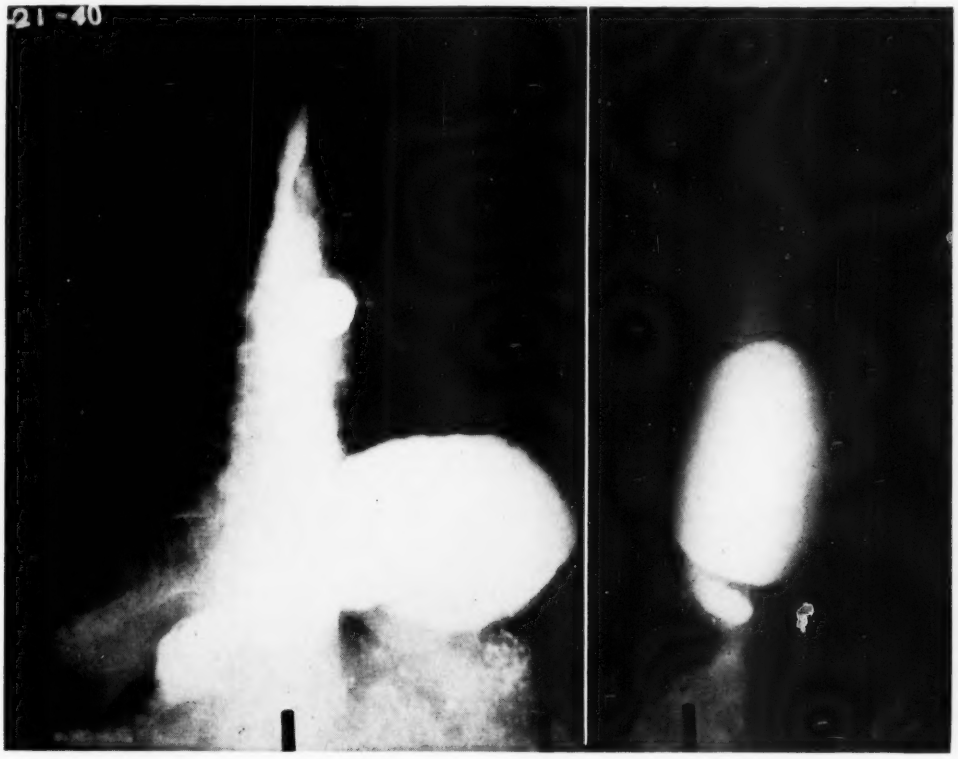

Fig. 1. Fig. 2.

Fig. 1.—Barium swallow in February, 1940, when patient first showed symptoms of dysphagia.

Fig. 2.—Barium swallow in August, 1946, after six years of conservative therapy. A complete obstruction of the esophagus is noted at the cardia with dilatation of the left epiphrenic diverticulum.

On Dec. 5, 1946, the first attempt was made at surgical correction of the patient's dysphagia. A conservative surgical policy was maintained throughout in order to reduce the risk to the minimum and at the same time correct the dysphagia and discomfort. For that reason the procedure recommended by Lahey in 1933 was employed. Under endotracheal cyclopropane-ether anesthesia the left side of the chest was entered through the bed of the ninth rib. The lower half of the posterior mediastinum was opened and the large epiphrenic diverticulum on the left side of the esophagus was dissected free. The most dependent portion of the diverticulum wall was markedly thickened from chronic inflammatory reaction and densely adherent to the diaphragm, requiring sharp dissection. The neck of the diverticulum was found to be about two inches in diameter and attached at the level of the junction of the middle and lower third of the esophagus.

The formerly dependent portion of the diverticulum was elevated and sutured to the posterior chest wall in a position which would permit drainage of the pouch by gravity. The pleural space was drained by a No. 28 French catheter under a water seal.

The anticipated relaxation of the cardiospasm by emptying the diverticulum and relieving the irritation of the diverticulitis and esophagitis did not occur. A rapid loss of

weight was again noted postoperatively, accompanying regurgitation of a large portion of food. This esophageal obstruction again proved refractory to dilatation, requiring another period of feeding through a Levine tube to prepare the patient for more radical surgical treatment. By this time it was assumed that the large defect in the mediastinum would have closed and the lung become adherent to the chest wall, thereby avoiding any very extensive fatal mediastinitis or empyema in case contamination of the pleura occurred.

Fig. 3.

Fig. 4.

Fig. 3.—Barium swallow in March, 1947, two and one-half months after gastrodiverticulum anastomosis. Decompression of the large diverticulum is noted with demonstration of a patent stoma between the diverticulum and stomach.

Fig. 4.—Barium swallow and gastric fill up in July, 1947, six months after anastomosis, still demonstrating a patent stoma.

The second operation was performed on Jan. 9, 1947, when a transthoracic gastroesophageal diverticulum anastomosis was made. The diverticulum was dissected free from the posterior chest wall and the fundus of the stomach delivered through a rent in the diaphragm. Between rubber-shod clamps a one-inch incision was made in the dependent portion of the esophageal diverticulum and in the fundus of the stomach. A three-layer anastomosis was made with interrupted fine silk sutures. The mucosal layers were approximated by the first row of sutures, the muscularis layers by the second, and the external surfaces of the walls of the two organs by the third row. This last row consisted of a few multiple tight sutures part way through each wall intended as tension sutures to relieve the main suture lines from the weight of the stomach. The line of anastomosis was covered with omentum brought up into the chest using a plasma and thrombin seal, according to the method of Devine. The pleural space was again drained with a No. 28 catheter through the tenth intercostal space posteriorly.

The postoperative course was uneventful except for a left lower lobe atelectasis relieved by a bronchoscopic aspiration on Jan. 11, 1947. All of the fluids were given parenterally for the first five days to avoid undue tension on the anastomosis from increased weight of the stomach. On the sixth postoperative day 30 c.c. of water were given every hour through the Levine tube which had been left in place in the cardia and previously used for gastric decompression. On the following day 50 c.c. of water an hour were well tolerated and by the eighth postoperative day 50 c.c. of beef broth hourly. A full liquid diet by mouth was started on the twelfth day without any signs of regurgitation or discomfort. The amount of morphine had been gradually decreased following each operation until no further narcotics were required after Jan. 18, 1947. Marked withdrawal symptoms occurred and required about one month to subside.

This patient was sent home on an extended furlough and has continued to take a regular diet without any regurgitation or discomfort for the past eighteen months since operation. Total blood protein in August, 1947, seven months postoperatively, was albumin 5.4, globulin 2.4, or an albumin-globulin ratio of 2.1:1.

Barium swallows revealed that the normal cardioesophageal route was patent and that the anastomotic channel functioned when the barium filled the distal esophagus to the level of the orifice of the diverticulum. The formerly large diverticulum was reduced to little more than a fistulous tract and the superior diverticulum on the right remained at about the same size. The same condition persisted in another barium swallow one year postoperatively.

COMMENTS

One of the most interesting features of this case is the fact that during the past seven years this patient has had practically all of the forms of treatment which have ever been recommended for epiphrenic diverticula except invagination and resection. Invagination is suitable for only very small diverticula and would be an impossibility in this patient. Only one case has been reported in which resection of the diverticulum has not been fatal. A resection in this patient would have been unsatisfactory due to the distal esophageal obstruction which would not have been immediately relieved by the resection and would probably have caused a disruption of the suture line from pressure within the obstructed esophagus. Since the most distressing symptoms related to epiphrenic diverticula are on the basis of the frequently associated cardiospasm a resection of the diverticulum could not be expected to offer any immediate relief.

Another possible method of treatment would have been complete resection of the distal third of the esophagus including all of the diverticula and the cardia of the stomach. The greater risk attendent upon such a radical procedure would seem to contraindicate its use in benign lesions if a more simple procedure is available to relieve the esophageal obstruction. Diverticula which occur on the right side could be brought out on the left for anastomosis.

CONCLUSIONS

1. A successful surgical treatment of a large epiphrenic diverticulum with esophageal obstruction and starvation from cardiospasm is presented.

2. A gradual increase in dysphagia and disability had occurred over a period of six years in this patient despite conservative treatment.

3. Surgical displacement of the diverticulum sac to facilitate employing of gravity proved ineffective in correcting this patient's dysphagia.

4. Gastroesophageal diverticulum anastomosis is suggested as the most satisfactory and safe method of correcting the esophageal obstruction and symptoms associated with such diverticula.

5. No previous report of the successful application of this method of treatment has been discovered.

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CHOLECYSTITIS EMPHYSEMATOSA

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CHOLECYSTITIS emphysematosa is an inflammation of the gall bladder with grossly discernible gas formation. It is a rare condition, although possibly not quite as rare as the small number of reported cases would indicate. A thorough survey of the literature shows that despite the fact that the first cases in which gas was found in the gall bladder were described by Stolz in 1901, since that time only fourteen additional cases have been reported. Stolz, in a study of "schaumorgane" reported three cases found at autopsy with gas in the gall bladder and bile ducts. The colon bacillus, *Bacillus lactis aerogenes*, and various other aerobes were recovered, but cultures for obligate anerobes were negative. He concluded that in these cases invasion of the gall bladder was terminal and gas formation a post-mortem feature. Whether these were true cases of emphysematous cholecystitis is doubtful. Of the subsequent cases in the literature, the first was discovered at autopsy, the second at operation. In 1922 Hallé and Marquézy reported a case which at autopsy showed gangrenous cholecystitis with perforation and a local false membrane walling it off from the free peritoneal cavity. Gas could be expressed from the gall bladder wall. Bacteriologic study revealed *Bacillus perfringens* in pure culture. The case discovered at operation was one reported by Kirchmayr in 1925. A fist-sized gall bladder was removed which was the seat of an acute phlegmonous inflammation with numerous small abscesses and crepitation of the thickened, edematous gall bladder wall. On culture Frankel's bacillus was obtained. The patient recovered. Kirchmayr was under the impression that this was the first case of gas bacillus infection of the gall bladder described.

It was not until 1931 that it was recognized that emphysematous change in the gall bladder wall and the accumulation of gas within or outside it will cast a diagnostic shadow on the roentgen film. The twelve remaining cases showed characteristic roentgenograms from which the diagnosis was or could have been made. Nevertheless, the entity is not well known. In the surgical literature only two reports are found, one by Hegner in 1931, the other by McCorkle and Fong in 1942. Hegner described the case of a 62-year-old man admitted with a five-day clinical picture suggestive of acute gall bladder disease. A roentgenogram two days after admission showed the gall bladder filled with air and a mottling of gas in the pericystic region. Two days later the gaseous area in the gall bladder region had increased to about four times its previous size. The patient was operated upon six days after admission. The x-ray impression of a gas-filled gall bladder was confirmed by the finding of gas within the gall bladder under sufficient tension to push the plunger out of the barrel of a 20 c.c. syringe. Only a cholecystostomy could be performed because of active bleeding

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which was encountered. The patient died suddenly four days after operation of a pulmonary embolus. Culture of the blood around the gall bladder mass and of the contents of the cavity proper showed pure cultures of an atypical *bacillus welchii.*

McCorkle and Fong discussed the significance of gas in the gall bladder and reported three cases of gaseous cholecystitis in which the diagnosis was made radiographically. In the first case, a 49-year-old man whose gall bladder was removed for acute cholecystitis, the significance of an elliptical gas shadow seen in the right upper quadrant on a plain film of the abdomen was appreciated only in retrospect. No observation for gas was made at the time of operation. The patient died of a fulminating gas infection of the abdominal and thoracic walls and peritoneum. Culture of the gall bladder was positive for *clostridium welchii* and *Bacillus coli.* The second and third cases presented quite similar clinical pictures and ran almost identical courses. Each was an adult male admitted with the clinical picture of acute cholecystitis of one day's duration. In each case the plain roentgenogram of the abdomen was negative on admission but on the day following the gall bladder was visualized as a gaseous shadow, the wall being outlined as a denser circumferential ring. Cholecystographic dye was not visualized. A fluid level was observed in each in the erect position. Some extension of gas into the surrounding tissues was observed in one of the cases. Both recovered without operation; sulfathiazole was given in one, sulfathiazole and gas gangrene serum in the other. *B. coli* and an anerobic spore-forming rod of the clostridium group were recovered from the duodenal drainage in one case, *B. coli, cl. welchii,* and a staphylococcus in the other. Roentgenologic evidence of gas persisted in both after clinical evidence of cholecystitis had disappeared.

The remaining cases in which the preoperative diagnosis of gaseous cholecystitis was made are found in the radiologic and sundry literature. In 1932 Simon reported a case of gaseous gangrenous phlegmon of the gall bladder in a 32-year-old man, diagnosed roentgenographically and corroborated at operation. Successive films over the course of several days showed progressive destruction of the wall with extension of gas outside it. A fluid level was observed in one of the films. The patient recovered following cholecystectomy. At operation gas and liquid with a fetid odor escaped when the abdomen was opened and the wall of the gall bladder was found to be completely gangrenous and pneumatic. On culture anerobic spore-forming bacilli in pure culture were obtained. Wybauw, in 1936, described the case of a 53-year-old woman with the syndrome of cholecystitis with stones and pericholecystitis. Clearly visualized in the right hypochondrium in a plain film of the abdomen was the contour of a sac, 15 by 6 cm., the wall outlined by gas, the lumen filled with stones. At operation gas was found essentially in the thickened wall. When the wall was cut, yellow, foamy, bubbly liquid was obtained. Cultures were not done. The course following cholecystectomy was remarkably smooth. Schmidt, in 1938, described the radiologic findings in emphysematous cholecystitis, including in his report Hegner's case and adding one of his own. This patient was a 37-year-old man with a history of intermittent right upper quadrant pain

combined with fever for three years. X-ray examination showed an elongated gas-filled area in the right hypochondrium. The gas-filled area filled faintly with dye on cholecystography proving it to be a poorly functioning gas-filled gall bladder. This patient recovered without operation. In 1940, del Campo and Otero reported the case of a 74-year-old man with gangrenous cholecystitis and a stone impacted in the ampulla. The hepatic ducts and biliary radicals as well as the gall bladder were outlined by gas. The patient was in desperate condition. Cholecystostomy was performed. The patient died four days after operation. *B. perfringens* was cultured from the gall bladder pus. Ramey and Scott, in 1942, published a survey of 110 cases of acute cholecystitis from 1931 to 1940. Without further description, they mentioned that the diagnosis of acute emphysematous cholecystitis was made in one case in a film without dye. Finally, in 1944, Stevenson reported three cases in which a gaseous gall bladder was visualized radiographically. In the first two cases the findings were corroborated at operation. The first was a 64-year-old man who recovered after the removal of a gangrenous gall bladder surrounded by a zone of gas. The second, a 63-year-old man, also recovered following cholecystectomy at which a gangrenous gall bladder containing gas under pressure was removed. The third case showed the typical x-ray findings of a gall bladder filled with gas. This last patient recovered under nonoperative therapy with gas gangrene serum, x-ray treatment, and sulfathiazole. Subsequent roentgenograms showed complete disappearance of the gaseous shadow previously observed.

The only additional references to emphysematous cholecystitis consist of a few brief comments. According to Walters and Snell, the diagnosis of gas bacillus infection of the gall bladder is seldom made in life and even at the operating table is not easily recognized although crepitation has been described. Mention is made of Simon's roentgenographic demonstration of pyopneumocholecystitis. Berg at the 5th International Congress of Radiology described cases in which gas was demonstrated in the biliary duct system by x-ray stating that one cause of this was infection of the biliary tract. And lastly, Hicken and Coray stated that the presence of gas within the gall bladder or regional bile ducts furnishes indisputable x-ray evidence of a gastrointestinal fistula provided one eliminates similar gaseous shadows associated with an emphysematous cholecystitis. No reference to gaseous cholecystitis is found in any of the standard texts on gall bladder disease (excepting Walters and Snell) or diagnostic roentgenology that were available. These include Rehfuss and Nelson, Rolleston and McNee, Robson, Bockus, Golden, and Feldman. In view of the paucity of reference material and the rarity of the condition it is felt that the presentation of another case and a discussion of the entity is warranted.

CASE REPORT

O. A. (No. 555223), a 68-year-old blind Negro woman, was admitted to the Surgical Service of Dr. A. S. W. Touroff, The Mount Sinai Hospital on Oct. 12, 1946. Two days before admission, following the evening meal, she had developed a dull, throbbing, nonradiating pain in the right upper abdominal quadrant. The pain had become increasingly severe and was accompanied by nausea and vomiting on taking anything by mouth. There were no chills, but fever developed after the first day. None of the various manifestations of jaundice had been

noted and there was no previous history suggestive of gall bladder disease or digestive disturbances of any kind. She had been a known diabetic for eight years and had been on a low fat diet and a daily dose of 25 units of protamine zinc insulinate. For five years there had been progressive loss of vision with complete blindness on admission. There was also a known history of hypertension.

Examination showed an acutely ill, febrile, obese woman who complained of severe right upper quadrant pain. The temperature was 101° F., the pulse 100 per minute, the respirations 34 per minute. There was total blindness and bilateral mature cataracts. The pupils were small and irregular. the left about twice the size of the right. They did not react and the fundi could not be seen. There were diminished breath sounds, dullness, and increased tactile fremitus over the right lower lobe of the lung posteriorly with an area of bronchovesicular breathing above. Occasional moist and crepitant râles were heard in the left axilla. The heart was markedly enlarged to the left. The rhythm was regular with sounds of good quality. A loud systolic blow was heard over the precordium. The blood pressure was 200/104. The abdomen showed moderate spasm and marked tenderness on the right, particularly in the upper half where a large rounded mass could be felt terminating indistinctly 7 to 8 fingerbreadths below the costal margin. There was no evidence of jaundice. The urine contained 2-plus sugar, 3-plus acetone, and was loaded with pus cells. The blood sugar was 280 mg. per cent, the urea nitrogen 18 mg. per cent, the chlorides 562 mg. per cent, the total protein 6 mg. per cent, the icteric index 3, the cephalin flocculation test negative, and the alkaline phosphatase 14 K.A. units. An electrocardiogram taken on admission showed evidence of rather severe myocardial damage.

A diagnosis of acute cholecystitis with pericholecystitis and possible hydrops or empyema was made. Because of the poor general condition of the patient, the uncontrolled diabetes, and the uncertain cardiac status, it was decided to treat her conservatively if possible until she could better withstand surgery. Penicillin therapy was started and measures to control the diabetes begun. A plain film of the abdomen two days after admission showed a remarkable picture. The gall bladder and proximal cystic duct were visualized as a pear-shaped gaseous shadow surrounded by a circumferential ring of gas representing the wall. A small amount of gas was seen outside the wall (Figs. 1 and 2). A roentgenogram of the chest showed marked enlargement of the heart, Fleischner's lines in both lower lobes, and an elevated right diaphragm which was seen to be mobile by fluoroscopy. Two days later (Oct. 16) the gas in the pericholecystic area had increased in amount. The entire cystic duct as well as the gall bladder could then be visualized. The gall bladder was no more distended than on the previous film and the gas within it seemed to be breaking up. The shadow cast by the wall was thicker and less clearly defined (Fig. 3). Parallelling this there was definite subjective and objective improvement in the abdominal picture, but phenomena of congestive heart failure developed temporarily as evidenced by bilateral congestive basal râles, increased venous pressure, and increased circulation time on Oct. 16. The cardiac picture responded to digitalis and mercupurin and the abdominal improvement continued. The temperature, irregular to 102° F. for four days, began to defervesce on the fifth, reaching normal by the seventh day. Within a few days of admission, the right upper quadrant mass was only vaguely palpable and by the eighth day all abdominal signs had disappeared. On Oct. 23 the patient was afebrile, general condition was excellent, the abdominal examination was negative, the chest was clear, and the venous pressure and circulation time were normal. Penicillin was stopped on this day. Her condition seemed adequate to withstand removal of the diseased gall bladder and operation was accordingly scheduled for Oct. 26, fourteen days after admission.

Laparotomy was performed through a slightly oblique right upper rectus muscle splitting incision under gas-oxygen-ethylene-ether anesthesia (Dr. Jemerin). When the peritoneum was opened, the stomach was seen to be broadly adherent to the undersurface of the right lobe of the liver. Through the stomach, the suggestion of a mass was palpable in the subhepatic region. After careful packing off of the abdomen, the stomach was bluntly separated from the inferior surface of the liver. A gush of gas under tension was suddenly encountered as the plane of separation was developed. Following this, about 4 ounces of bile-stained pus were

sucked out of the cavity that had been exposed. After the pus had been evacuated, the stomach was completely separated from the liver, exposing the gall bladder. Practically the entire wall of the gall bladder was seen to be gangrenous and necrotic. The bulk of the pus had come from within the organ, but some had been contained in a well walled-off pericholecystic abscess cavity which communicated freely with the interior of the gall bladder through defects in the necrotic wall. The organ contained a number of small and medium-sized

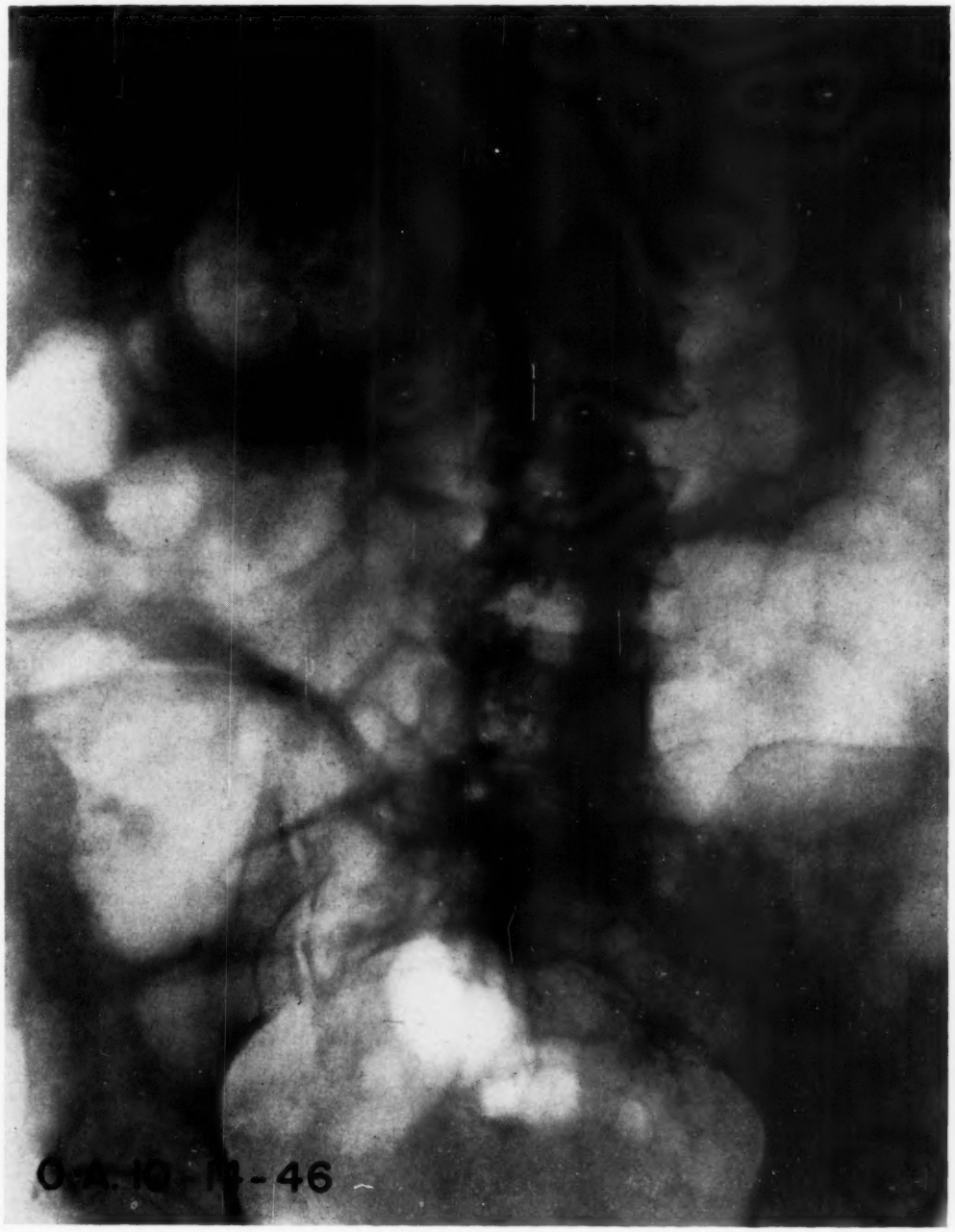

Fig. 1.—Plain film of abdomen, Oct. 14, 1946, showing gas-filled gall bladder in right upper quadrant with circumferential ring representing wall.

stones including one which was impacted in the cystic duct. The gall bladder was freed from the liver bed by subserosal dissection from the fundus proximally. The cystic duct and vessels were identified and ligated individually. The duct was divided and the gall bladder removed. The stomach was examined carefully at its site of adhesion to the liver and gall bladder but no evidence of perforation could be found in this organ or in the transverse colon or duodenum. The subphrenic space was seen to be sealed off by adhesions between the anterior surface of the liver and the anterior parietal peritoneum. Because of the high diaphragm seen by x-ray examination these were separated bluntly and about 10 ounces of turbid fluid were obtained. A cigarette drain was inserted over the dome of the liver into the subphrenic space and a second along the gall bladder bed into Morison's pouch. The wound was closed in layers. Aerobic and anerobic cultures were made of the gall bladder pus. The pathologic report on the gall bladder was acute gangrenous and subacute cholecystitis; cholelithiasis.

Fig. 2.—Right upper quadrant film, Oct. 14, 1946, showing gas filling proximal cystic duct as well as gall bladder, ring shadow of wall darker than shadow of gas in lumen, and streak of gas outside wall.

The postoperative course was entirely uneventful until the tenth day despite the fact that the patient pulled out the drains on the second day after operation. Penicillin, started again with operation, was stopped on the seventh postoperative day and the smooth, afebrile course continued. The wound healed by primary union, the abdomen was soft and nontender, and the patient felt fine and was taking nourishment well. On the tenth day there was a sudden chill with a temperature rise to 104.4° F. followed by a second chill four hours

Fig. 3.—Right upper quadrant film, Oct. 16, 1946, showing entire cystic duct now visualized while shadow cast by gall bladder gas is not as homogeneous as in preceding film; wall shadow is thicker and less clearly defined, and considerably more gas is seen in the pericholecystic region.

later. A blood culture taken at the height of the fever was positive for *B. coli* (*Clostridium oedematiens* had been obtained in pure culture from the gall bladder pus.) Treatment with sulfadiazine, penicillin, and blood transfusion was instituted and the temperature became normal in two days. However, the following day, the thirteenth after operation, there was a convulsion which left in its wake signs of a cerebral accident. There were left-sided Hoffmann and Babinski signs, left-sided hyperreflexia and ankle clonus, and the patient became semi-comatose. At about the same time oliguria developed. The sulfadiazine was stopped. During the next few days the coma deepened, and this and the oliguria made the diabetes difficult to control. Wide swings between acidosis and hypoglycemia occurred. The patient never aroused from the coma but nevertheless lingered remarkably, dying on the twenty-fourth day after operation, eleven days after the cerebral accident. Permission for an autopsy without brain examination was obtained. The findings were as follows: The operative site and subphrenic spaces were clean. There was no abdominal wall infection. Evidence of hypertensive heart disease and cardiac failure were present. The heart was hypertrophied and dilated, the coronary arteries sclerotic and narrowed, and there were a left hydrothorax, a serous pericardial effusion, and a small amount of ascites. Multiple pulmonary artery thromboses involving the smaller branches were found. There was a left pyonephrosis with a complete ureteral obstruction at the ureteropelvic junction due to soft "stone" composed of necrotic, greenish-yellow detritus the counterpart of which was also found covering the surface of the calyces. The "stone" was not examined for sulfadiazine crystals. The cause of death was considered to be a cerebral accident on either a vascular or hypoglycemic basis.

Comment.—This case of clinical acute cholecystitis with pericholecystitis showed the typical roentgen features of emphysematous infection. Gas was seen to fill the lumen of the gall bladder, to outline the wall, and to extend into the surrounding tissue. Because of uncontrolled diabetes and congestive heart failure, the immediate therapy was conservative. Apparent clinical subsidence of the acute phase was achieved. Operation was performed after two weeks at which time the diabetes and cardiac status were well controlled, the patient was afebrile, and the abdominal signs had disappeared. Empyema of the gall bladder and pericholecystic abscess containing gas under tension were found. *Cl. oedematiens* in pure culture was obtained from the pus. The gall bladder was necrotic and contained stones, one of which was impacted in the cystic duct. A right subphrenic collection was also found. The gall bladder was removed, and the subhepatic and subphrenic spaces drained. The postoperative course was entirely smooth for ten days, the wound healing per primam and the operative site remaining soft and nontender. A chill with high fever occurred on the tenth day with a blood culture positive for *B. coli.* Penicillin therapy was started immediately and within two days the temperature was normal. However, on the thirteenth day a severe cerebral accident occurred. The patient developed oliguria and lapsed into coma from which she never roused, dying on the twenty-fourth day after operation. Left ureteral obstruction with pyonephrosis was found at autopsy, probably accounting for the transitory *B. coli* bacteremia. The operative site was clean and death was attributed to the cerebral accident.

DISCUSSION

Cholecystitis emphysematosa is an acute inflammation of the gall bladder due to gas-producing organisms with resultant gross accumulation of gas within

the wall and lumen of the organ and frequent extension outside it into the pericholecystic area. The gas produced is demonstrable radiographically. The culpable organism is almost always one of the anerobes of the clostridium group.

That there is a significant incidence of clostridial infection of the gall bladder is not sufficiently appreciated. While this is due in large part to the failure to make routine bacteriologic studies, to a certain extent it is bound up with occupation with concepts of the pathogenesis of gall bladder disease which place emphasis elsewhere, such as upon noninfectious aspects of gall bladder inflammation or upon a special streptococcal affinity for the viscus (Rosenow, and Magner and Hutcheson). It lies beyond the scope of this paper to discuss in any detail the complex and confusing problems of either the bacteriology or pathogenesis of infection of the gall bladder. However, for whatever light they may cast upon the entity under discussion, they will be touched upon briefly.

Infection of the gall bladder is now usually considered to be a secondary occurrence. In acute cholecystitis, the most important primary factor is probably obstruction of the cystic duct. Bockus goes so far as to state that there is almost universal agreement that acute cholecystitis is nearly always primarily dependent upon obstruction of the gall bladder. However, other factors may also act primarily to provide the proper soil for bacterial growth and in chronic cholecystitis these are probably more often at fault than obstruction to the outlet. There has been a resurgence of the importance of chemical factors in recent years, and changes in the normal condition of the organ such as are produced by stasis, by ulceration, by calculi, by anoxia, or by vascular occlusion may also conceivably provide the appropriate *mise en scène*.

It must not be forgotten, however, that even though secondary, the most frequently manifested and encountered lesions of the biliary tract are those with infection. Once the stage has been set, then, bacteria must reach the organ. Various routes by which this may be accomplished have been postulated. Whipple summarized these as follows: (1) By the portal stream to the liver; the bacteria which survive the phagocytic action of the reticuloendothelial cells enter the bile capillaries from which they have access to the gall bladder, or, entering the liver lymphatics the bacteria pass from these to those of the subserous coat of the gall bladder; (2) by way of the hepatic artery; (3) by retrograde lymphatic infection from the appendix, colon, or duodenum (very little experimental proof of this has been offered); (4) from contiguous inflamed organs; (5) by ascending infection from the duodenum through the papilla of Vater.

The bacteriologic findings vary considerably with different investigators. In general a high percentage of all diseased gall bladders were infected. Positive cultures were obtained much more frequently from the gall bladder wall than from the bile or gallstones. Wilkie found positive cultures in acute cholecystitis in 84 per cent of the gall bladder walls but in only 40 per cent of the gallstones. Whipple's cultures were positive in 22 of 25 cases of acute cholecystitis and in 79 of 147 cases of chronic cholecystitis. Magner and Hutcheson obtained positive cultures in 89 per cent of the walls of 200 gall bladders

removed at operation. The fluid contents of 106 of these were cultured, with positive results in 33 per cent. In addition they tabulated the findings of ten other investigators. Including their cases, cultures were done on 938 walls. The positive findings varied with the different investigators from 32 to 89 per cent, with an average of 63.4 per cent. The fluid contents were cultured in 1,340 cases. Of these, 12 to 58 per cent were positive, with an average of 34.7 per cent. Three-quarters of the cases of acute cholecystitis of Branch, and of Nickel and Judd yielded positive cultures. Andrews, culturing 91 gall bladders of which 24 were normal or relatively so, obtained positive cultures of the wall in 43 per cent and of the bile in 33 per cent. Rehfuss and Nelson collected 4,395 cases of which 2,162 had been studied bacteriologically. More than 45 per cent of the walls and 29 per cent of the fluid contents had been found to be infected.

The most commonly encountered bacteria were streptococci, colon bacilli, and staphylococci. The role of the streptococcus in gall bladder infection was sometimes stressed. Rosenow, for instance, in addition to finding a high clinical incidence, felt that he had demonstrated an elective affinity experimentally, while Magner and Hutcheson stated that chronic cholecystitis in man is due in most cases to a streptococcus intramural infection. The actual incidence of the Welch bacillus or of other gas-forming anerobes of the clostridium group in cholecystitis is uncertain. Most cases of gall bladder disease are not investigated bacteriologically, many studies do not include anerobic cultures, and the methods of culture vary and are sometimes open to question when these have been included. The finding of reports of individual cases of gas bacillus infection of the gall bladder throughout the literature would indicate that some impression of such infection being rare or unusual must exist. Thus, Spitznagel in 1929 reported a case in which at autopsy a necrotic, serofibrinous gas bacillus cholecystitis was found. The necrotic areas were full of gas bacilli and from the blood and bile Fränkel's bacilli were obtained in pure culture. In 1933 Koch reported one case of acute cholecystitis with empyema. Fränkel's bacillus was cultured from the pus but there is no mention as to whether active gas was seen at operation. Löhr commented on Koch's case in another article in the same year. In 1937 Meister reported a case which at autopsy showed an acute cholecystitis due to Fränkel's bacillus but in which no accumulation of gas was observed.

On reviewing the reports of investigations of the bacteriology of cholecystitis for the frequency of occurrence of gas-forming anerobes, this was found to vary markedly even in those studies in which specific attention was apparently paid to these organisms. However, the impression of a definite, appreciable incidence is obtained, the variations, while wide, being easily explicable on the basis of differences in material and methods. Some idea of the percentage frequency can be obtained from the following studies. Rosenow, in 1916, found the Welch bacillus together with other bacteria in the gallstones of 7 of 33 patients. In the gall bladder wall, it was recovered from only 1 of 33 patients. In 1923 Brütt reported the recovery of gas bacilli from the bile and pancreas

of a case with a stone impacted in the common duct and pancreatic necrosis. In a systematic investigation of 130 cases of cholecystitis he found gas bacilli in two additional cases of acute necrotizing cholecystitis. Wahlberg, in 1927, in a bacteriologic investigation of about 1000 operated cases of gall bladder disease found infection due to Fränkel's gas bacillus in 4 of them, 2 of which had already been reported by Brütt. He concluded that the gas bacillus was not uncommonly found in gall bladder disease, and was of pathologic significance in many cases producing acute cholecystitis, which, however, did not always go on to gangrene. Branch, in 1929, found the Welch bacillus in 8 per cent of the walls, 7 per cent of the stones, and 5 per cent of the fluid contents of a group of diseased gall bladders. In 1930, Gordon-Taylor and Whitby reported on their bacteriologic studies in 50 cases of cholecystectomized gall bladders. They found *B. welchii* in 18 per cent of them, usually associated with acute cholecystitis, and concluded that intestinal bacteria were the most frequent organisms found in gall bladder infection. In Magner and Hutcheson's series of 167 cases showing some grade of cholecystitis, the wall of only 1 case was positive for the Welch bacillus. However, Andrews and Henry concluded after their bacteriologic studies in 1935 that *B. welchii* was frequently present in the bile and walls of both normal and diseased gall bladders. Including both normal and diseased gall bladders, *B. perfringens* was encountered in 9 to 11 per cent of the cases. While *B. coli communis* was encountered more often, when gas formation occurred they felt it was most likely due to *B. welchii* as the colon bacillus is not likely to produce gas in the gall bladder because of lack of oxygen. In Rehfuss and Nelson's series of 4,395 collected cases which included various of those just mentioned, many of the authors did not mention *B. welchii* or found it in only a small percentage of cases. However, in some of the reports included its incidence was appreciable and other intestinal bacteria were quite common in all. Rehfuss and Nelson concluded that one great group of bacteria in cholecystitis are those found in the bowel.

Thus it would seem that infection of the gall bladder by intestinal bacteria, regardless of the avenue of spread, is common, and since *Cl. welchii* is one of the normal inhabitants of the bowel, one would expect infection by this organism not to be uncommon. The Welch bacillus has been found in the bile and wall of both normal gall bladders and gall bladders in which some other bacterium is obviously the primary and predominant infectious organism. Infection by *Cl. perfringens* depends upon the presence of an area of local tissue damage that provides suitable soil for anerobic growth and this in turn almost always depends upon the presence of stones which produce anoxia by ulceration, obstruction, or vascular occlusion.

When infection by *Cl. welchii* occurs, it may vary from one that is mild to an acute fulminating cholecystitis with gangrene of the wall and extension to adjacent organs and the blood stream. Gas may or may not be produced, and when it is discernible grossly, we have the entity known as cholecystitis emphysematosa. As a corollary, when gas is found in gall bladder infection it is almost always due to infection by organisms of the clostridium group. Only Stolz

in the cases reviewed did not find obligate anerobes, and he concluded that gas formation in his cases was a post-mortem feature and that Fränkel's gas bacillus was by far the most important cause of gas formation in the tissues. While *B. coli* is very commonly found in disease of the gall bladder it does not usually produce gas under the conditions present in gall bladder infection.

Pathologically, emphysematous cholecystitis is an acute, usually gangrenous, inflammation of the gall bladder wall with bacteria growing in the wall and producing gas. The wall crepitates and foamy fluid can be expressed from it. The lumen of the organ fills with infected fluid and gas accumulates there as well, replacing the fluid contents partially or entirely. Destruction of the wall with extension of infection outside the gall bladder is quite common, so gas-producing pericholecystitis is also to be expected.

The clinical picture is that of a severe acute cholecystitis, with pericholecystitis in a high percentage of the untreated cases. A characteristic shadow on the plain roentgen film of the abdomen makes the diagnosis. During the first twenty-four to forty-eight hours, usually no gas can be seen. There then appears the dark, pear-shaped shadow of gas outlining the usually distended gall bladder with the wall of the organ demarcated by contained gas as a darker circumferential shadow. Stones may be visualized as positive or negative defects within the gas. A fluid level should not be uncommon in films taken in the upright position. Within a few days the gaseous collection within the wall may become broader and stratified, and streaks or blobs of gas in the surrounding tissues may be seen indicating extension of the infection into the pericholecystic area. The biliary ducts and radicals are not customarily outlined by gas. Only in del Campo and Otero's case was this seen. When recovery takes place without surgery, absorption of the gas is gradual, the shadow persisting long after clinical evidence of cholecystitis has disappeared. According to McCorkle and Fong, the luminal contour is lost first, followed by shrinkage and disruption into bubbles of varying size of the gas in the wall and lumen of the viscus.

Differentiation must be made from a fistulous communication with the gastrointestinal tract which is much more common. When such a communication is the cause of air in the biliary tract, the gall bladder is usually of normal size and the biliary duct system as well as the gall bladder casts a gaseous shadow on the roentgenogram. This is in contrast to the enlarged gall bladder shadow surrounded by a denser ring representing the gas within the wall and the spread into the surrounding tissues that characterize gaseous cholecystitis. Lipomatosis of the gall bladder wall may also occasionally cast an x-ray shadow simulating the circumferential ring. This may be differentiated by the absence of gas within the lumen and by the day-to-day changes.

Treatment should be surgical but not all authors are in agreement with this point of view. McCorkle and Fong prefer nonoperative therapy with chemotherapeutic agents and specific sera in the acute phase and state that both interval and early operation should be avoided if possible because of the danger of dissemination of infection. In support of this they reported three cases (vide supra). One of these patients died of a fulminating gas bacillus infection

of the abdominal and chest walls after cholecystectomy; the other two recovered under a conservative regime, sulfathiazole in one, sulfathiazole and gas gangrene serum in the other. However, analyzing the remainder of the cases in the literature from the point of view of treatment and mortality, it is seen that of 3 patients treated conservatively 1 died, compared to 2 deaths out of 6 treated surgically, or, including our case, 3 deaths out of 7. (In one of the reported cases neither the type of therapy nor result was stated.) The small series gives no basis for choice between the two approaches. It does not seem, though, that fundamental surgical principles are being satisfied by permitting a diseased, infected stone-containing gall bladder, which would be removed in any other case, to remain in situ because the infecting organism is the Welch bacillus. This is particularly so because the inflammation is frequently gangrenous, going on to destruction of the gall bladder wall and extension outside it. Moreover, if chemotherapy can stop the spread of infection without surgery, it should be equally efficacious in preventing extension within the abdomen or the abdominal parietes after surgery. The deaths following operation were in no way due to the dissemination of infection that McCorkle and Fong feared except in their fatal case where the nature of the infecting organism was not recognized. Hegner's patient died of a pulmonary embolus, del Campo and Otero's patient was in desperate condition at the time cholecystostomy was performed and probably should not have been operated upon in that state, and in the case reported here cerebral accident was the cause of death. On the other hand, Hallé and Marquézy's patient, who died without operation, died of uncontrolled infection. At autopsy not only was a perforated gall bladder with pericholecystic abscess found, but there were a right pneumonitis and several gangrenous areas in the omentum also due to *B. perfringens*.

Whether surgery should be done in the acute phase or in the interval is a moot point in ordinary gall bladder surgery and cannot be decided conclusively for this variety of acute cholecystitis either. It would seem that if chemotherapy will control the acute infection that it would be wise to wait until this has subsided. However, with evidence of beginning spread beyond the confines of the gall bladder, prompt surgical intervention would seem to be the logical course to follow. Cholecystectomy is the operation of choice and should be performed whenever the general condition of the patient and the local findings will permit. Chemotherapy should of course be used in conjunction with surgery.

SUMMARY

1. The literature on cholecystitis emphysematosa is reviewed.

2. A case of cholecystitis emphysematosa is reported.

3. The bacteriology, pathology, roentgen features, diagnosis, differential diagnosis, and treatment of the entity are discussed.

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VOLVULUS OF THE CECUM

An Appeal for Primary Resection, with Report of Six Cases

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In a remarkable article concerning volvulus of the cecum, based upon over 300 cases, Wolfer, Beaton and Anson come to the conclusion that this form of intestinal strangulation is not so rare as is generally assumed. Its practical importance results from the fact that even in operated cases the death rate is higher than 50 per cent. Early intervention is therefore necessary. Provided the affected bowel is still in sufficient vital condition, untwisting and cecostomy is recommended as the procedure of choice. Resection is considered too dangerous "for any patient in not unusually good condition." When the bowel is necrotized the exteriorization of the involved sector becomes necessary.

Similar views are generally prevalent. River and Reed pleaded for derotation and cecopexy. The same point of view was sustained by Turner and Grey and many others.

My personal experiences with cecum volvulus, based upon six cases, the main details of which are given in Table I, have led me to quite different practical conclusions. In not one of my cases did the general conditions correspond to those which Wolfer and associates have stipulated as necessary for the advisability of resection. They presented, rather, the features of severe intestinal strangulation. In two of them (No. 5 and 6) gangrene and fetid peritonitis were present. Nevertheless in all the five cases where resection was done, success was obtained. However, in No. 1 this intervention had to be completed two days afterward by a temporary ileostomy. Two and one-half years before, the patient had had a similar attack lasting for at least five days. At that time I had only untwisted the volvulus. The distended cecal pouch containing a large quantity of air and 800 c.c. of extremely fetid fluid was fixed to the anterior abdominal wall. The following day a colostomy at the ascending colon and later an ileostomy was deemed necessary. Recovery followed after nearly 2½ months of hospitalization. In this case the anatomic conditions of cecal volvulus showed unusual features. Generally this kind of ileus is caused by twisting of the cecum round the longitudinal (vertical) axis of the right colon. But in this case the cecum, together with the ascending colon, had turned around the horizontal axis of the transverse colon with the effect that the base of the cecum was turned high up to the liver, so that the posterior face of the bowel confronted the anterior abdominal wall* An abnormal mobility not only of the cecum but of the whole right colon is of course necessary to make such an extensive rotation possible. In fact an

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*This case was therefore reported as volvulus of the transversal colon, in Beitr. z. klin. Chir. **160**: 588-590, 1934.

TABLE I

NO.	AGE (YR.)	SEX	DATE OF OPERATION	ONSET OF DISEASE	ANATOMIC FEATURES	COMMENT	KIND OF OPERATION	RESULT	DATE OF DISMISSAL
1	41	♀	10/23/32	3 days	Upward rotation of cecum and ascendens (see text)	Recurrence after similar attack 2½ years before (see text)	Resection with consecutive ileostomy	Cured	12/ 1/32 (after 39 days)
2	45	♂	6/16/38	several days	Classic type	—	Resection with termino-terminal ileocolostomy	Cured	7/ 2/38 (after 16 days)
3	42	♂	6/ 7/40	10 days	Classic type	—	Resection with termino-terminal ileocolostomy	Cured	6/21/40 (after 14 days)
4	28	♂	6/12/40	2 days	Classic type	Recurrence after similar attack 5 years before, nonradical operation had been made at that time	Resection with termino-terminal ileocolostomy	Cured	6/25/40 (after 13 days)
5	47	♂	7/25/42	5 days	Classic type	General condition extremely bad, intestinal paralysis, generalized fetid peritonitis (see text)	Untwisting, appendectomy; closure of partly torn cecal wall; ileostomy	Death at the end of operation	—
6	34	♂	12/ 7/43	1 day	Mixed type (see text)	Turbid and fetid hemorrhagic peritoneal fluid, extensive gangrene of the cecal wall	Resection with termino-terminal ileocolostomy; drainage of the peritoneal cavity	Cured	12/23/43 (after 16 days)

ileocolic mesenterium commune extending to the whole right colon was present in this case; a real hepatic flexure coli did not exist. In Case 6 the same type of cecum volvulus was combined with the usual torsion of the cecum around the longitudinal axis of the right colon. The common type of cecum volvulus was seen in Cases 2, 3, 4, and 5.* In all of them the abnormal mobility of the cecum was due to the presence of an ileocecal mesenterium commune. Unlike Case 1 the ascending colon in these cases was fixed more tightly than usual to the posterior abdominal wall. As the cecum in these cases always shows a marked dilatation, the abnormally fixed ascending colon forms a kind of handle on which the hypermobile cecal pouch is suspended. This particular state can certainly be considered as a further predisposing factor to the occurrence of volvulus. In all these examples (Cases 2 to 5) the twist was clockwise.

With regard to the prognosis of cecum volvulus it is important to know that no strict relation exists between the duration of the strangulation and its effect upon the vitality of the twisted bowel. For example in Case 3 ten days had not been sufficient to produce a serious local damage, whereas in Case 6 extensive gangrene had developed in twenty-four hours. The intensity of strangulation is therefore primarily responsible for the rapidity of serious anatomic alterations. The optimistic opinion of River and Reed, that in volvulus of the cecum the "early symptoms are mild, slowly progress, and that signs of intra-abdominal inflammation are late," can therefore not be accepted as a general rule. In the case of Valentine and Kinnear (1937) reported by Wolfer and associates death had occurred in five hours. Early surgical intervention is therefore absolutely necessary in my opinion.

As pointed out before, in five of my cases, primary resection was done with good results. Only in the previous attack of Case 1 was my choice the simple untwisting with cecopexy. The result was, as already mentioned, not very satisfactory. It was necessary for the patient to stay in the hospital not less than 2½ months and the recurrence was 2½ years later. In Case 5 desperate general conditions of the patient made a radical intervention impossible. Diffuse fetid peritonitis was present with enormous meteorism of the lesser bowel. The anterior wall of the distended and twisted cecal pouch showed a long rent of serosa and muscularis with prolapse of the gangrenous though not yet perforated mucosa. The peripheral end of the appendix was equally gangrenous, caused certainly by its participation at the volvulus. Nothing else could be done than to untwist the volvulus to close the partially ruptured cecal wall with sutures, and to remove the appendix. Enterostomy was done and an enormous quantity of feculent fluid came out of the inserted tube. But at the same time the state of the patient grew worse and when the closure of the abdomen was completed the patient died.

TECHNIQUE OF THE RESECTION

My experiences reported here show that the resection of the twisted cecum is far from being so dangerous as it is usually supposed. The good results I

*Cases 2 to 4 have been reported in my paper Contribution à la chirurgie du colon, J. Suisse de méd. 73: 33, 1943.

obtained are probably attributable in the first place to the technical procedure, that is the reunion of the intestinal stumps with termino-ileocolostomy.

Of all possible methods this procedure is the most simple and time saving because a single row of well-adapted serosa-muscular sutures can be quite adequate for a safe reunion. Additional suture of the mucosa might be better still. Incongruity between the lumina of colon and ileum has sometimes been alleged as an argument against this method. The objection is certainly not justified in cases of cecal volvulus, for there exists always a marked distention of the ileum, so that its lumen is generally of equal size with the colon. Personally I have employed this procedure for many years, which is not even mentioned in some well-known treatises of surgical technique, but which has been recommended by Turner and Grey as a method of choice for the resection

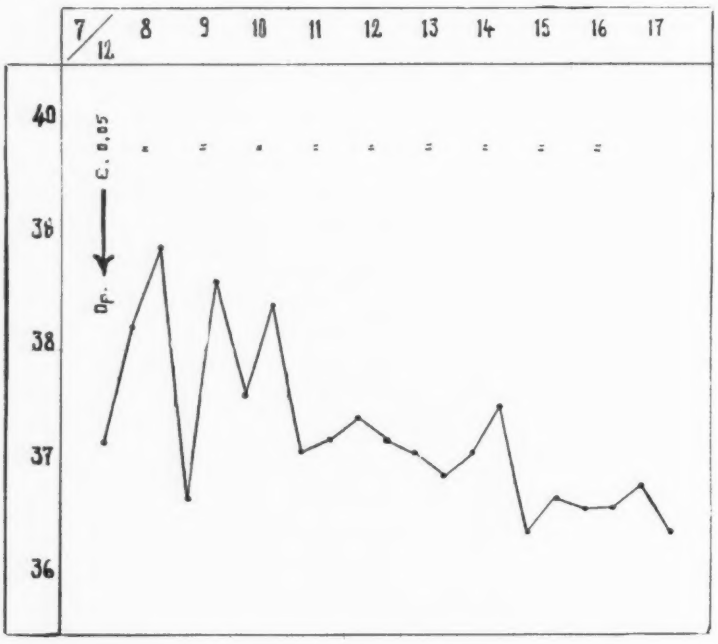

Fig. 1.

of the right colon. The previously mentioned tight fixation of the ascending colon to the posterior abdominal wall which is prevalent in cecal volvulus cases gives a special indication for this kind of resection because any other method of ileocolic anastomosis would necessitate first a mobilization of the fixed ascending colon or even a considerable enlargement of the resection up to the transverse colon. Under the often critical conditions of intestinal obstruction this would cause at least a loss of time, which could influence a fatal result. That primary resection can give satisfactory results even in the presence of partial gangrene of the twisted cecum with peritonitis is shown by Case 6 (Fig. 1). An exteriorization of the damaged bowel, as Wolfer and co-workers have recommended, would have been less satisfactory because the temporary

ileocecal preternatural anus which results from this procedure is not well tolerated by the patient, due to insufficient utilization of the ingesta and to the inevitable irritation of the surrounding skin. And finally it demands further operative measures for the closing of the intestine. Primary resection is therefore much better and time saving. For instance in Case 6 the patient could be dismissed from the hospital sixteen days afterward as perfectly cured. Also in the three other cases of terminoterminal resection (Cases 2, 3, and 4) the time needed for full recovery was short (sixteen, fourteen, and thirteen days respectively), whereas in Case 1, where laterolateral resection was done, this period took thirty-nine days.

Another fact which indicates a preference for resection in preference to simple untwisting of the volvulus is that the latter exposes the patient to the risk of recurrence. Neither a temporary cecostomy nor the different methods of cecopexy can be considered as reliable measures against such an incident. Even in my small series of six cases, two of the patients (Cases 1 and 4) were operated upon for recurrent volvulus.

This certainly high disposition to recurrence after nonradical operations is not surprising, for the same experiences have resulted with sigmoid-volvulus. In Turkey this kind of ileus is very frequent and recurrence after simple fixation is extremely high. One can see in these cases that the large fibrous adhesions resulting from the operative fixation later assume the shape of long strings, unable to prevent any further recurrency of the volvulus.

EMETINE AND PERITONITIS

It is possible that the good result which, in spite of the presence of cecal gangrene and fetid peritonitis, was obtained in Case 6 might be to some extent attributable to the use of emetine in that case. For in a series of publications, the first issued in 1943, I was able to show that this drug, far from being alone the classic medicament of amebic dysentery and its purulent complications, can be very effective also against various nonspecific septic infections. Perhaps the most interesting point is that it can be successful also in penicillin-resistant cases, primarily those due to *Bacterium coli*. Experimental investigations made by Bernoulli confirmed my clinical findings. Nevertheless this new utilization of emetine has not yet received serious consideration.

CONCLUSIONS

1. Of six cases of cecum volvulus, five patients were treated with primary resection of the twisted bowel.

2. All these recovered although one case was complicated with gangrene and peritonitis. In a still more severe case the patient did not sustain the nonradical intervention.

3. On the whole these results are better than those generally obtained with distortion with or without cecostomy and/or cecopexy.

4. The nonradical operations expose the patient to the danger of recurrence.

5. Primary resection can claim, therefore, the superiority in the treatment of this emergency.

6. The possible use of emetine as a supplement following operative procedure ought to be considered.

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THE PREVENTION OF ABDOMINAL ADHESIONS

Experimental Study on the Role of Gastrointestinal Motility

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THE formation of adhesions involves basic and fundamental processes of healing, the nature of which is not completely known. The known factors include many variable ones, such as general health and nutrition, infection, trauma, either chemical, mechanical, or thermal, the presence of foreign bodies, and the blood supply to the parts. It is known that certain individuals heal with more scar tissue than others, and that certain tissues form more scar in their healing. Bowel motility is another factor, but has received little attention up to this time. These many variable factors as well as the lack of uniformity in methods of production of adhesions cause difficulties in the experimental approach to the problem. A standardized, reproducible method for the production of adhesions has been lacking. Similarly, there should be some agreement on the procedure for estimating the number and density of the adhesions produced. Only in this way can there be proper evaluation of methods reported for the prevention of adhesions. Clinically, there is the added difficulty in obtaining well-controlled series of cases for study.

In the past, study of the prevention of abdominal adhesions has been largely confined to the use of various solutions placed in the peritoneal cavity. Little experimental work has been done to investigate the relationship of the formation of adhesions to the motility of the gastrointestinal tract. Many workers[9, 27] have had the impression that adhesions would be more likely to form if the bowel were allowed to remain quiet after an abdominal operation. However, we have been unable to find systematic or clear-cut laboratory or clinical experiments substantiating this impression. Vogel[27] in 1902 stated that it would be desirable to give physostigmine (eserine) to increase gastrointestinal motility. Massie,[16] in 1945, in connection with his work with heparin, used Prostigmine in the postoperative treatment of his patients who had been operated upon for intestinal obstruction due to adhesions. Apparently he used the Prostigmine to prevent ileus and not for its value in the prophylaxis of adhesions. Since there had been no experimental work to support the idea that intestinal motility and adhesions may be related, it seemed that there was need for an investigation of this problem. It also seemed important to determine what early feeding and perhaps early ambulation, by their effect an motility, could be expected to accomplish in the prevention of abdominal adhesions.

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REVIEW OF THE LITERATURE

For a complete summary of the literature up to 1942 the reader is referred to the excellent review by Boys.[2] Numerous methods[7, 23] for the prevention of peritoneal adhesions have been proposed. Of course, the avoidance of the known causative agents mentioned previously will do much to reduce the number and density of adhesions formed. In spite of the exercise of care in the elimination of these factors, adhesions do form in many individuals. For this reason additional means of prevention have been studied. The problem has been approached mainly in four ways. These are: (1) the reduction of the amount of peritoneal injury from surgical trauma and infection, (2) attempts at removal, dissolution, or dilution of the fibrinous exudate, (3) the prevention of the formation of fibrin, and (4) the separation of peritoneal surfaces.

Reduction of Peritoneal Injury.—Reference has already been made to the reduction of peritoneal injury by avoiding trauma. Well known to all surgeons is the importance of gentle handling of tissues, the avoidance of excessively hot sponges,[10] and the elimination of foreign bodies such as drains, and various chemicals in the peritoneal cavity. There have been numerous attempts[8] to reduce the amount of peritoneal infection by the local application of sulfonamides. It appears, however, that the sulfonamides themselves are responsible for adhesions.[3, 6, 24] The instillation of penicillin solution into the peritoneal cavity has been employed by us in both military and civilian work. This method seems to reduce the incidence of infection and therefore the possibility that adhesions will develop. Used systemically, penicillin, sulfonamides, and streptomycin are also of value in preventing peritoneal infection and the adhesions which frequently follow.

Removal of Fibrin.—Papain, a digestive ferment, has been tried in an attempt to dissolve fibrin. Several experimental and clinical reports showed good results with this substance.[18, 19, 22] Later work, however, failed to substantiate the value of this ferment in preventing adhesions.[18]

It was noted many years ago that adhesions did not form in the presence of pus. This phenomenon was ascribed to the digestive activity of ferments in the leucocytes. Amniotic fluid, which causes an outpouring of leucocytes when placed in the peritoneal cavity, was tried in an attempt to utilize this property of the leucocytes. While several investigators were encouraged by their results,[22, 28] others found that amniotic fluid was of little value in reducing the number of adhesions.[12, 13, 15]

Prevention of Fibrin Formation.—Citrate solution[21] and heparin[12-16] have been suggested for inhibiting the formation of fibrin. Experimental and clinical work with the former substance have given rise to controversial opinions. It is at present considered to be of little value. Heparin, on the other hand, has several proponents, among them Lehman and Boys.[12] They have a good deal of experimental and clinical work in support of their views that heparin is beneficial in preventing the formation of adhesions. They instilled heparin into the peritoneal cavity at twelve-hour intervals for three days by means of an inlying catheter. Their experimental reports seem encouraging, but the recent work of

Bloor and associates[1] has not substantiated them. Furthermore, the hazards of harmful side effects are, I believe, too great to warrant its general use. Lehman and Boys[14] themselves reported one postoperative death due to hemorrhage from the administration of heparin. The other disadvantages, aside from hemorrhage, are the possibility of delayed healing and the spread of infection. In addition, the catheter used for the instillation of the heparin is a foreign body which, in itself, can act as an irritant. Massie,[16] who used heparin in seven clinical cases, reported either retarded wound healing, infection, or hemorrhage following five of the eight operations performed (one of the patients was operated upon twice). In summary, it can be said that heparin is not only of questionable value but its use entails definite hazards.

Separation of Peritoneal Surfaces.—In an attempt to keep apart the peritoneal surfaces, numerous coatings such as membranes, oils, and related substances have been applied to the serosal surface of the bowel but with very little or no success.[2] It was hoped by some investigators that the instillation of hypotonic, isotonic, or hypertonic solutions or blood into the peritoneal cavity would be beneficial. Some encouraging results were obtained by Buchbinder[4] and Totten[25] but the results of Oehsner[19] and Lehman[12, 13] were equally discouraging. Injection of air into the peritoneal cavity has likewise not proved beneficial. The use of omental grafts has been found helpful in covering raw surfaces.[17, 26]

The effect of motion of the viscera on the formation of adhesions has been given too little attention. It was to this problem that our study was directed. Could one prevent the initial agglutination and subsequent fibrous union of the mesothelial surfaces by keeping the viscera in motion? The most physiologic method of keeping the bowel in motion is to stimulate peristalsis by food or drugs, or both. With this in mind the literature was searched for reports of such investigation.

Aside from some early inconclusive work, no clinical or experimental data have been presented to substantiate the idea that immobility of the bowel is a factor in the formation of abdominal adhesions. Vogel,[27] in 1902, expressed the belief that lack of peristalsis led to the formation of adhesions. He therefore recommended the use of cathartics in the immediate postoperativee period. He tried this method on rabbits but he gave no statistical analysis of his results. He also administered physostigmine (eserine) subcutaneously along with gum arabic intraperitoneally in several clinical cases as well as in animals. In this work the gum arabic was always used along with the physostigmine and the results were very inconclusive. Busch and Bibergeil[5] shortly afterward expressed doubt as to the value of the physostigmine and gum arabic used by Vogel.

Kroh[11] and Kirchberg[9] reported good results in breaking up adhesions by using a large vacuum bell on the anterior abdominal wall. Alternate suction and pressure were applied to the bell in order to move the viscera and stimulate peristalsis. Payr[20] gave a suspension of iron by mouth to animals and then moved a powerful magnet across the abdominal wall. The intestines containing the iron were observed to move with the magnet. He found that adhesions pro-

duced in animals could be broken up in this way. He also used this method in two women to whom the iron suspension was administered per rectum.

PROCEDURE

Adhesions were produced in the peritoneal cavity of dogs by spreading 0.25 Gm. of surgical talcum powder over the serosal surface of the small intestine. This amount of talcum powder was found, by preliminary experiments, to produce a moderate number of adhesions. Larger amounts of talcum powder, up to 2.0 Gm. caused almost complete obliteration of the peritoneal cavity due to the adhesions. The animals were divided into two groups. In one group every effort was made to stimulate peristaltic activity of the bowel by means of early feeding and the repeated administration of Prostigmine methylsulfate hypodermically. In the other group an attempt was made to depress peristaltic activity by means of starvation and the repeated administration of atropine hypodermically.

EXPERIMENTAL WORK

Experiments were performed upon sixteen dogs weighing 8 to 14 kilograms. The animals were anesthetized with nembutal administered intravenously. Under aseptic conditions, the abdomen was opened by means of a right rectus incision measuring approximately 8 cm. in length. The abdominal cavity was explored for pre-existing adhesions, after which the entire small bowel was exteriorized and placed on a moist towel. Then 0.25 Gm. of dry sterile talcum powder was evenly distributed by means of a salt shaker on one side of the serosal surface of the small bowel, segment by segment. The bowel was then carefully replaced into the peritoneal cavity in such a manner as to prevent talcum powder from being rubbed off onto the drapes or the edges of the incision. The abdominal wall was closed in layers using silk sutures. Postoperatively, each dog was placed in an individual cage.

The dogs were then divided at random into two equal groups by the laboratory assistant.

Group A.—These dogs were encouraged to eat very early after the operation. Most animals ate within eight to twelve hours. Each dog received an initial subcutaneous injection of 0.5 mg. of Prostigmine methylsulfate and subsequent injections of 0.25 mg. every four hours night and day for forty-eight hours. These amounts of prostigmine were well tolerated. Larger doses of Prostigmine were used in earlier experiments but they proved to be toxic.

Group B.—These dogs were not given any food or water by mouth for forty-eight hours. Instead, subcutaneous injections of 5 per cent glucose in saline solution were given twice daily during this forty-eight hour period. In addition, each dog received subcutaneous injections of 0.5 mg. of atropine sulfate every four hours for forty-eight hours. No symptoms of atropine poisoning were noted.

The animals from both groups were active shortly after the anesthesia had worn off, that is, they had early ambulation. All animals were allowed a normal diet and activity with no medication after the first forty-eight hour period.

Exploration was carried out on the dogs in four to six weeks. A count was then made of the number of adhesions of the bowel, mesentery, and omentum. The density and ease of separation of these adhesions were estimated and graded as 1 to 4 plus (4 being the maximum). If an adhesion was more than 1.5 cm. wide, it was counted as two adhesions, regardless of its width. The small bowel was photographed at the time of this examination.

RESULTS

The results of the experiments are summarized and tabulated in Table I and Chart 1. Representative photographs of the bowel of several of the dogs are shown in Figs. 1 to 8. In Group A (stimulated bowel motility) the average number of adhesions produced was 5.1; that in Group B (depressed bowel motility) was 17.4. As can readily be seen there were 71 per cent fewer adhesions in the group in which the motility of the bowel was stimulated. There was also a significant reduction in the density of the adhesions formed. This conclusively shows that there is a greater production of adhesions when the bowel is inactive. Stimulation of the activity of the bowel, on the other hand, results in a reduction in the number and density of adhesions formed.

TABLE I. TABULATION OF RESULTS OF EXPERIMENTS ON PREVENTION OF ADHESIONS

DOG NO.	NO. OF ADHESIONS	DENSITY OF ADHESIONS
	Group A. Food and Prostigmine	
1	3	+
2	10	+
3	6	+
4	8	+++
5	5	+
6	6	+
7	3	+
8	0	0
Average	5.1	+
	Group B. Starvation and Atropine	
9	20	++++
10	16	++++
11	27	+++
12	9	+++
13	25	++++
14	9	+
15	15	++ to +++
16	18	+ to ++
Average	17.4	+++

The effect of early feeding without using Prostigmine was also investigated in three dogs, using the same technique as in the previous groups. These animals were found to have more adhesions than those that were given prostigmine in addition to early feeding. Since re-exploration was carried out on the dogs after only two weeks, and the series was small, no definite conclusions can be drawn. It appears, however, that Prostigmine per se is of value in reducing the number of adhesions.

DISCUSSION

In the attack on the problem of the prevention of abdominal adhesions, too little attention has been given the relationship of gastrointestinal motility to

the formation of adhesions. Several investigators have indicated that they believe that intestinal motility is desirable in the prevention of adhesions. However, experimental proof for this belief has not heretofore been satisfactorily presented. The experimental work presented in this paper shows a definite diminution in the formation of adhesions in dogs in which intestinal activity was stimulated by food, water, and Prostigmine, as compared to dogs in which peristaltic activity was depressed.

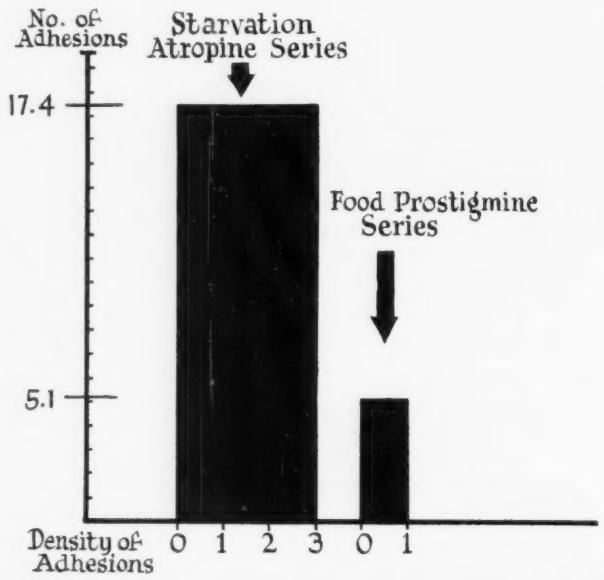

Chart 1.—Number and density of adhesions in the group with relative inactivity of the gastrointestinal tract in contrast to the group with relative activity of the gastrointestinal tract.

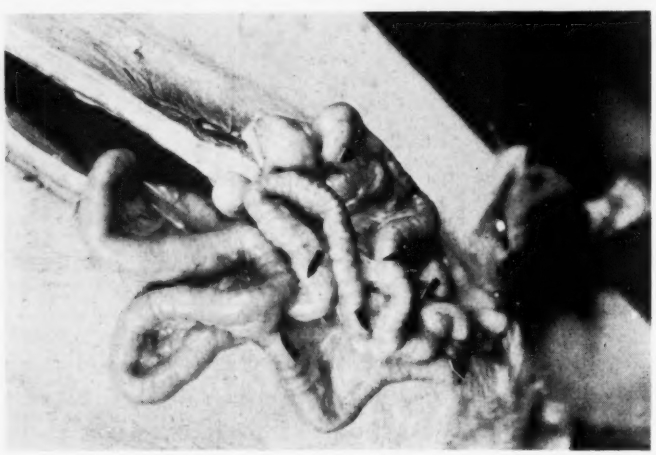

Fig. 1 (Dog 9).—Note large number of adhesions (indicated by arrows).

The experiments cited have clinical implications. By early feeding and perhaps early ambulation we can expect to reduce the number of postoperative adhesions in clinical cases. Prostigmine is, we believe, a valuable adjunct to early feeding in stimulating peristalsis. This increased activity does not allow the

Fig. 2 (Dog 13).—Note large number of adhesions (indicated by arrows).

Fig. 3 (Dog 15).—Note large number of adhesions (indicated by arrows).

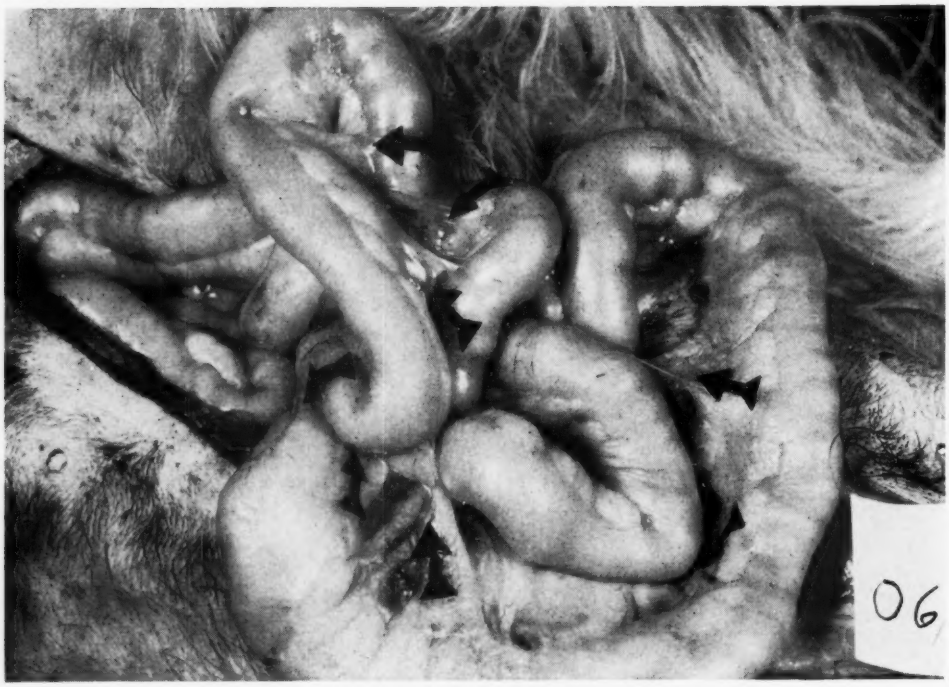

Fig. 4 (Dog 16).—Note large number of adhesions (indicated by arrows).

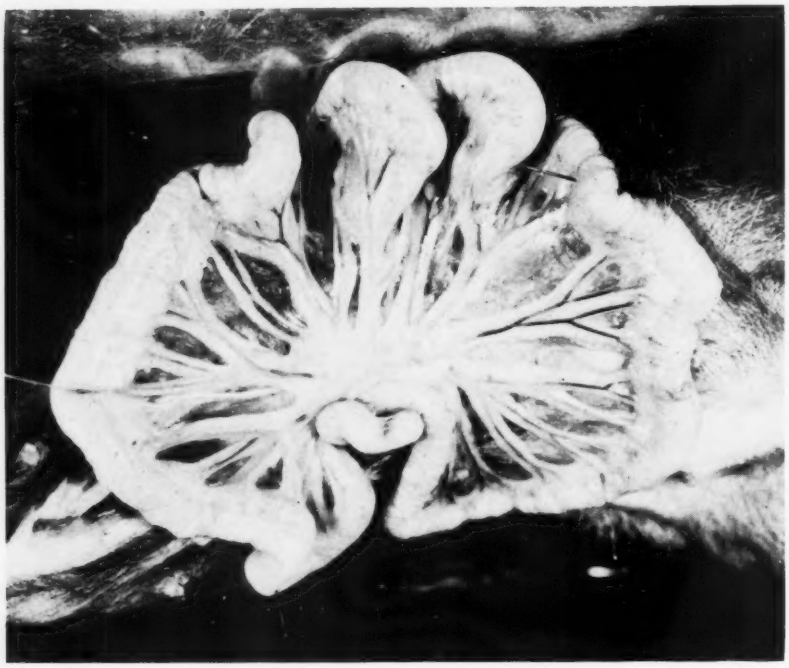

Fig. 5 (Dog 1).—Note the scarcity of adhesions (none visible in exposed part of specimen).

Fig. 6 (Dog 6).—Note small number of adhesions (three are indicated by arrows).

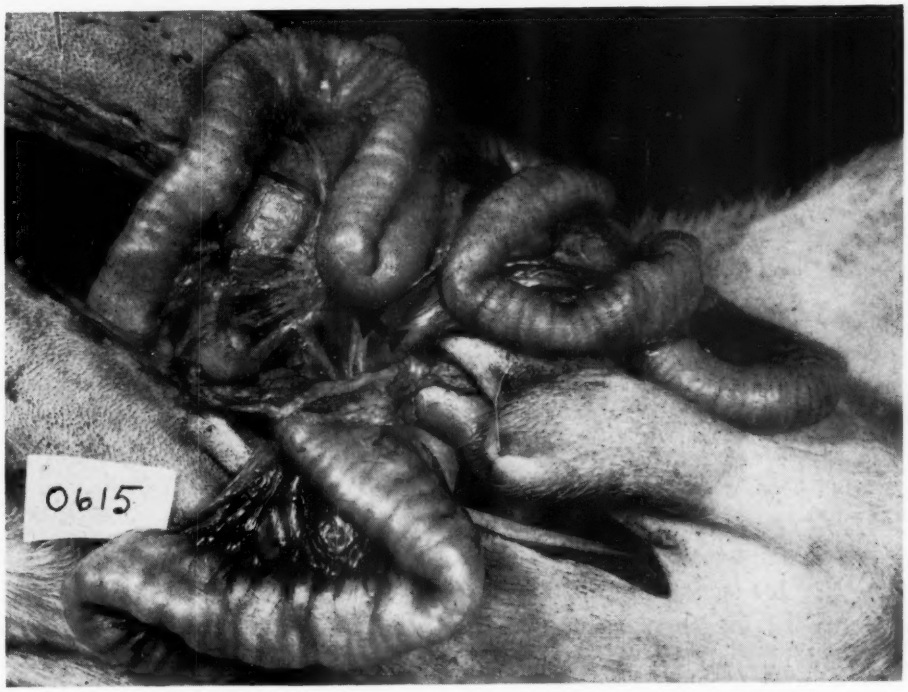

Fig. 7 (Dog 7).—Note small number of adhesions (two are indicated by arrows).

peritoneal surface of the bowel to remain adherent to other mesothelial surfaces long enough to permit fibrous union. Conversely, ileus, by producing paresis or paralysis of the bowel, favors the formation of fibrous union. If the fibrinous agglutination of the surfaces can be prevented during the first few postoperative days, then the formation of fibrous adhesions will be checked since Hertzler has shown that mesothelium is healed in four to seven days.

Fig. 8 (Dog 8).—Note complete absence of adhesions.

It is true that there may be contraindications to early feeding and the use of Prostigmine. Many surgeons would be reluctant to employ this regime following gastrointestinal anastomoses. However, bowel resection and anastomosis are not required in most cases in which operation is performed for relief of intestinal obstruction due to adhesions. It is in this type of case that constant stimulation of peristalsis would be especially indicated.

SUMMARY

1. The importance of gastrointestinal motility in the prevention of adhesions has been assumed but never adequately proved heretofore.

2. Intra-abdominal adhesions were produced in sixteen dogs by distributing talcum powder on the surface of the small bowel.

3. In the dogs in which peristaltic activity of the bowel was depressed, an average of 17.4 adhesions was produced by the talcum powder.

4. In the dogs in which peristaltic activity of the bowel was stimulated by early feeding and Prostigmine, an average of 5.1 adhesions was produced by the same amount of talcum powder.

5. There was a 71 per cent reduction in the number of adhesions produced in the group of dogs in which peristaltic activity was stimulated.

6. Early feeding supplemented by hypodermic injections of Prostigmine are valuable aids in the prevention of abdominal adhesions.

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SOME PSYCHOSOMATIC ASPECTS OF THE MANAGEMENT OF SURGICAL PATIENTS

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PSYCHOSOMATIC medicine has become widely accepted among both the laity and the medical profession at large, but it is probably true that many surgeons have not thought of applying its principles to their practice. This paper is based on experiences with patients who represent a fair cross section of the population of a large city. The emphasis will be on the management of neurotic patients. However, most people have psychologic weak spots, and most surgical patients can be considered apprehensive, anxious people, reacting emotionally rather than rationally.

The ideal response to a projected operation would be a calm acceptance of the procedure as the means of overcoming a disease process, with the expectation that while it will be an unpleasant experience, it will be tolerable. The patient would be expected to cooperate willingly and to bear with fortitude a certain amount of discomfort. Most patients, however, respond with fear and anxiety. There is a variety of reasons for this.

The patient may fear death—he knows of people who have died after operations. The old joke that "the operation was a success but the patient died" seems to occur to a great many patients facing surgery. Further evidence of how widespread this fear is can be seen in the frequency with which patients make wills at this time. Most people only make a will when considering the possibility of dying.

The very excellent public campaign to awaken people to the danger of early cancers has created widespread cancer phobia. To some, the mention of a tumor is almost equivalent to announcement of death.

The fear of disfigurement is common. Such fear is expected in patients requiring surgery on an exposed part of the body, but frequently discussion of scars comes up even with abdominal operations.

Financial factors create anxiety in some patients. Separation from the family during hospitalization worries many, especially mothers, children, and those who have dependents at home.

The fear of loss of function is prominent in many patients, especially those who are to have genital, orthopedic, and limb operations.

It is an axiom in psychiatry that childhood experiences condition the responses of the adult. Traumatic experiences with surgery in childhood are particularly apt to leave psychic scars. The young child is vulnerable and fragile psychically, as well as physically, if not more so. It is not unusual to see a child screaming with terror or pain taken from his bed to the operating room, where he is surrounded by strangers dressed in queer clothes; he is forcibly restrained and is in a state of terror as he goes into unconsciousness. When he awakens, he may be in acute discomfort and again in strange surroundings

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separated from his parents. These are all psychic traumas to the child, who is usually unable to comprehend the necessity of the procedure.

Some children learn the terror of surgery when they receive the news that a parent is to have an operation. During these times the household is upset, routine destroyed, the other parent agitated, and there is general apprehension. This arouses similar anxiety in the children. Similarly, some children are frightened by witnessing or experiencing accidents and suffering.

Occasionally, a well-intentioned but unthinking parent makes some remark about "cutting it off" when the child is observed masturbating or manipulating his genitals. Sometimes other children discuss damage to the genitals from such manipulation. The young child, perhaps 3 to 6 years old, retains the fear of cutting but often forgets the specific part mentioned. This fear in turn becomes unconscious, only to be reactivated when a surgical procedure is contemplated, particularly involving the genitals. This consideration is particularly important for those doing pediatric surgery.

Children conditioned in any of the ways just mentioned become the adults terrified by the idea of cutting.

Some fears about surgery have been discussed. There are patients who, in contrast, seem to welcome operation. There are varied reasons for this. An operation is a dramatic event; the patient becomes the center of attention, surrounded by attendants, doctors, nurses, and relatives, and is able to command unusual indulgence. Some people seem to welcome punishment, particularly when they suffer from feelings of guilt. The operation and its pain may satisfy the need for expiation. Menninger has pointed out the frequency with which a suicidal drive occurs in people not obviously abnormal. In some cases, multiple operations, with their risk of death, may satisfy this self-destructive tendency in a socially acceptable way. Numerous abdominal scars may serve as a warning that psychiatric, rather than surgical, treatment may be needed.

THE PREOPERATIVE INTERVIEW

The preoperative interview offers the best opportunity for patient and surgeon to appraise each other. It will probably be most valuable if the patient is allowed to talk freely while the surgeon listens. If the patient seems apprehensive, he can be asked what he is afraid of. In this way, one can learn the patient's experiences and associations with surgery. Many of the fears voiced by patients seem hopelessly irrational, but if they are to be dispelled they must be taken seriously. His fears are, after all, part of the patient, part of his fundamental attitudes, and as such will affect his responses during the ensuing weeks.

Certain common fears were enumerated previously. The fear of dying is generally best met with an emphatic statement about the insignificant mortality rate and the overwhelming probability of survival. It is probably better never to mention the possibility of cancer as a reason for operation. If the patient has been worrying about cancer and brings up the subject, or if the possibility has been discussed by someone else, it can be countered with

a positive statement about the overwhelming probability of a benign tumor, or a successful removal of the tumor if it should prove malignant. When the patient knows that the diagnosis is cancer, the brilliant results that have been achieved with some cancer surgery may be stressed. When the diagnosis is certain, the family will need coaching on how to handle the patient. Discussion with surgeons reveals great differences in the technique of handling cancer patients. The best method depends on the personalities of both patient and surgeon.

It is probably always preferable to stress the simplicity and ease of the technical aspects of the operation. Occasionally, a surgeon tries to justify a large fee, or builds up his own importance in the patient's eyes by talking of the difficulty of the operation and how his experience and skill will be needed to overcome the hazards. Unfortunately, the patient generally retains the idea that the operation is difficult and therefore dangerous, and his fears are intensified.

Some patients remember with horror their own or others' suffering during the postoperative period. Many have heard about the miseries of gas pains, the difficulty of bed pans, the dreadful weakness, the tubes used for drawing urine, the needles stuck in the vein, fainting, etc. It will be helpful, therefore, to tell the patient very simply that postoperative pain and discomfort can now, in large part, be obviated.

Early ambulation is being used more widely. However, patients unfamiliar with this technique are sometimes frightened by being asked to get out of bed a day or two after a major operation. This anxiety will not occur if the surgeon says before the operation that he may wish to have the patient up in a chair one or two days postoperatively.

The fear of disability can be dealt with at the preoperative interview. It is common for patients to fear alteration of the sex life after such operations as hysterectomy, prostatectomy, ovarian or testicular operations, or even herniorraphy. A simple explanation by the surgeon that the sex life will not be appreciably affected, the potency will not change, that there will be no castration effects is usually sufficient. Some patients fear that digestion will be permanently crippled after an intestinal operation. The statement that prolonged dietary restriction will not be needed might dispel this fear before it becomes established. Patients who are to have hernia or orthopedic operations often need to be assured that there will be no residual weakness. Those who need a colostomy can be told that, while every effort will be made to preserve the rectal sphincter, the modern colostomy can be made to function with minimum nuisance.

The preoperative interview may also enable the surgeon to spot the patient who needs psychiatric evaluation before operation. The patient with a history of multiple operations has already been mentioned. Preoperative psychiatric consultation is probably advisable for many patients who are to have thyroidectomy, operation for intractable peptic ulcer, for cholecystitis without stone or biliary dyskinesia, chronic appendicitis diagnosed on the basis of intermittent right lower quadrant pain, and for those with a history of

multiple sinus operations. Those who insist on beautifying plastic operations on nose or breast when these are not conspicuously ugly are often in need of psychiatric help in order to overcome feelings of inferiority, wrongly focused on some physical blemish.

Psychologic trauma in childhood, once well-established, may be impossible to overcome. It can be minimized by careful prophylaxis. Children are best prepared for operation by being told as much as they can understand about the procedure. Its necessity can be explained relatively simply. They should be told that it will be done while the child is not conscious. If the child is old enough, the difference between unconsciousness and sleep should be explained. This will avoid the frequent postoperative fear of going to sleep in children who have been told conscientiously, but inaccurately, that they will be put to sleep for the operation. If time permits, children can be allowed to act out the operative procedure using a doll. The doll can be put to bed, kept there for several days, and some of the hospital procedures, such as bandaging, done by the child. The youngster thus becomes somewhat familiar with events to come and regards them as part of a game. Every effort should be made to allow the mother to stay with the child before operation and immediately afterward. The need for affection and reassurance is perhaps greater at this period than at any other in the ordinary life of the child.

THE PERIOD IN THE HOSPITAL

The Preoperative Period.—A friendly, uneffusive anesthetist can help both patient and surgeon. It is extremely desirable that the anesthetist visit the patient the night before to explain in detail what is to happen during the patient's conscious period before operation. He can mention the benefits of the sedative given the night before and the hypodermic to be administered in the morning. It is sometimes necessary to mention the shaving which will be done. Shaving the pubic hair before abdominal operations frightens some patients who assume that some additional genital operation is projected. If infusions or transfusions are to be done, it is well to tell the patient about them beforehand and to reassure him that these do not indicate a dangerous situation—that they are used very freely in modern surgery since they are, on the whole, painless and effective. He can stress the ease of induction of anesthesia. People who had operations in the days when induction was a frightening, strangling procedure have never forgotten it. Some patients fear that guilty secrets will be revealed while going under or emerging from anesthesia. They often signal this apprehension by making some joking reference to it. The anesthetist can comment casually at this point that while a few patients babble, their remarks are usually unintelligible.

The Day of Operation.—Not infrequently, on the morning of operation the hospital routine leaves the patient without breakfast, without company, without any possible source of comfort except the preanesthetic medication, while he waits apprehensively for the summons to the operating room. Since it is impossible to time operations to the minute, the patient is sometimes moved to the anesthetic room where he remains in fear and suspense for many long

minutes. It would be helpful if the patient were allowed to stay in his room until the anesthesia is ready for him. If he must wait, some reassuring person, either relative or attendant, should be available to talk to him quietly and reassuringly. Anesthetics like pentothal sodium and avertin administered in the room are valuable for the particularly apprehensive patients, since they go to sleep and wake up in their own beds, and are spared the anxious period of preparation for operation. Patients deeply appreciate the surgeon who manages a visit for a few reassuring words just before the operation.

Too often, patients under spinal anesthesia are allowed to hear details of their pathology or to hear the surgeon scolding his assistants because something has gone wrong. The patient hearing this may fear that he is being handled by incompetent people. If the patient is to be conscious in the operating room, it might be a good rule for the operating staff to say only what the patient would be happy to hear or, a very poor second best, to plug the patient's ears. Often the mirrors or the glass around the light over the table permit the patient to watch the operation, to his great horror. A wet cloth over the eyes will protect him.

The Postoperative Period.—Once fully conscious, patients benefit from a prompt visit by the surgeon. This is the most opportune time to tell the patient how well the operation went, to describe the benign pathology, and to mention that the operation was thoroughly desirable. Some surgeons make it a practice to display the surgical specimen. It might be better to avoid this unless the patient requests it. These specimens scare and disgust many laymen, although they rarely mention their aversion and even pretend enthusiasm to the proud surgeon.

It is common practice to use routine medication orders for the postoperative period. One of the cardinal tenets of psychosomatic medicine is that patients are individuals, not only psychologically but physiologically. Not only do different patients vary widely in their response to medication, but the same patient may vary in his response at different times, depending on other medications, the amount of pain, and the degree of anxiety or depression. Accordingly, there is a need for making medication specific to the individual and the occasion. It is not rare to see a patient narcotized, confused, and helpless because of the excessive use of morphine and the barbiturates. Careful explanation of pain will enable some patients to disregard certain discomforts which might otherwise become important, and thus decrease the need for sedation. The patient can be told that he may have analgesics, but that they are best used moderately for the sake of his own clarity of mind. Another patient, on the other hand, may require reassurance about analgesics because he fears the possibility of addiction or of "being doped," or because he has suffered from the effects of excessive dosage.

In some institutions the use of infusions and transfusions has become far too much a routine matter. Frequently patients are given parenteral fluid, although perfectly capable of taking it by mouth. Relatively few years ago, transfusions were a major event. More than one transfusion was regarded

as certain evidence of a desperate situation. The anxiety based on ignorance of recent surgical practices might be prevented if the worried patient were told that transfusions are used these days almost as freely as tonics were used a generation ago.

There are several psychologic advantages in early ambulation. The patient who is allowed out of bed knows that his condition cannot be very serious. The postoperative weakness associated with prolonged bed rest is minimized, and the patient is able to go home stronger, fully ambulatory, more nearly able to cope with his problems, and has a shorter convalescence.

Early ambulation also permits earlier, freer feeding. Postoperative feeding is important and, like medication, needs more individual prescription. Abstinence from food and unpalatable food are psychologically bad for some patients, particularly those who have a tendency to obesity and those who normally pay much attention to food. Food for many people is a great source of solace and comfort, even under ordinary conditions. In many institutions the postoperative diet is often unpalatable, unseasoned, served unattractively or cold, is offered without reference to the patient's likes or dislikes, and surprisingly often has little food value. Meals are usually served at 7 A.M., 11:45 A.M., and 4:30 P.M., hours to which the patient is unaccustomed and which he often finds very irritating. Medically too, this is an unsatisfactory schedule, since it imposes a fourteen hour fast on a weakened patient. It might be better, both physiologically and psychologically, to provide frequent small feedings of highly nutritious, easily digested, nonirritating, low-residue material, such as well-cooked cereal, lean meat, fowl, bread, egg, plain cake, custards, crackers, etc. It is probably true that hospital stay can be appreciably shortened by insistence on adequate nutrition. Also, many patients are convinced that unless they eat, they will be weakened, that the bowels will not function adequately, that they will indeed become sicker. These people, especially, need a closer to normal diet.

Patients spend much of the day looking forward to the surgeon's visit. They are comforted by being told that the wound is healing nicely. They appreciate being asked about pain, discomfort, and any irritations they may have with the hospital and ward procedures. A running conversation with the patient during the dressing serves the dual purpose of distracting the patient's attention from the wound and, at the same time, allows the surgeon to discover those details which mean the difference between the patient who is resting comfortably most of the day and one who is frequently uncomfortable and irritated. Perhaps complications of wound healing are better left unmentioned unless imperative. Certainly nothing should be discussed in front of the patient which might create apprehension—particularly dreaded diagnoses. It has been observed frequently after ward rounds conducted in unguarded fashion that some patients give evidence of their perturbation by tachycardia, weeping, sudden loss of appetite, and other evidences of emotional disturbance.

Rusk and others have pointed out the lack of care with which the convalescent phase of the hospital stay is managed. There are many devices

which can be used to occupy the patient's interest. Reading and listening to the radio are the simplest and most universally applicable. Card games with friends, relatives, or neighboring patients may offer pleasant distraction. The occupational therapist can offer many suggestions for handicraft which can be managed by most conscious patients. Unless distracted, the patient often focuses his attention on the details of the operation and on his discomforts. Pain and discomfort increase sharply when much attention is paid to them, and become minimized when given less attention.

Postoperative psychologic disturbances are not rare and may be immediate or delayed for weeks. They include depressions, elations, paranoid reactions, toxic delirious states, and confusions. Perhaps the most common is depression. In examining forty patients who had uncomplicated pelvic surgery, Lindemann showed that thirteen exhibited restlessness, insomnia, agitation, and preoccupation with depressive thought content beginning three to four weeks after operation and lasting more than three months. Postoperative depressions are often not obvious. The symptoms may include any combination of the following: sadness, apparently unprovoked tears, disturbed sleep despite absence of pain, undue quietness, apathy, lack of willingness to talk, unusual irritability, excessive fearfulness about the operation, about affairs outside the hospital, or about the future, and personal slovenliness in normally fastidious people. The most important contribution that the surgeon can make toward the management of the depression is to recognize it and meet it frankly and with sympathy. Perhaps the surgeon will prefer to ask the family physician or a tactful, intelligent friend or relative to talk to the patient. Perhaps the surgeon can find the time to allow the patient to talk out his sorrows and can try to encourage and reassure him. It is important to guard against oversedation with depressed patients. Not rarely it causes further depression and confusion. Small doses of amphetamine given early in the morning are occasionally helpful, but if the patient becomes more agitated it should be stopped at once.

If the patient is actively psychotic, a psychiatrist should be called in immediately.

THE CONVALESCENT PERIOD

Psychologically it is always preferable to allow maximum activity as soon as possible. It is therefore wise to ask the patient to do as much as is safe at the earliest possible time, in the hospital as well as at home.

Patients frequently have questions about the amount, kind, and duration of work that they can do safely. They wonder about the details of nutrition, about exercise, and about coitus. These questions can be discussed before the patient leaves the hospital. Once home, the patient often calls the family physician for subsequent advice. Confusion and conflict can be avoided if the surgeon lets the physician know what directions he has given. Many patients continue to think of themselves as sick, as long as a special diet is maintained. It is probably preferable not to restrict the diet unless there is a specific indication. Most patients can be made to feel more comfortable and more confident if they are urged to take such progressive daily exercises as will not

cause undue fatigue. Tolerance can be built up with astonishing speed if the patient is asked to go through some simple procedure at regular frequent intervals during the day.

The question of vacations arises frequently. It is the habit of many surgeons to suggest that the patient go away for a so-called rest. But going away is often an uncertain business. The patient may be uncomfortable in a strange bed. Minor postoperative complications may cause undue alarm because the patient is separated from his physician. The patient may be bored, and the food may be unusual or distasteful to him. Many postoperative vacations are periods of irritation and boredom which contribute little or nothing to the patient's recovery.

FURTHER COMMENTS

Many surgeons are unquestionably too busy to give their patients the amount of time and care suggested here. These men might consider the use of trained residents and assistants to do a considerable part of the pre- and postoperative care. In some instances, the surgeon may prefer to ask the family doctor to take over this function, since he is more familiar with the personality and individual medical idiosyncrasies of the patient. For ward patients, these functions are best delegated to the house surgeon or resident. It would help him remember that patients are people, not cases of gallstones or hernia, and would strengthen his preparation for practice.

Little or none of the foregoing is new or controversial, but these ideas, although perhaps accepted intellectually, are often forgotten or ignored. The thesis of this paper is not that patients should be babied or coddled, but that they should be treated as human beings with weaknesses as well as strengths. The patient who is adequately prepared for the psychologic sequelae of his operation will suffer less from psychologic invalidism, will have a shorter and more comfortable convalescence, and will not dread surgical events in the future. The good surgeon is also a good physician. The good physician ministers not only to tissue pathology but to the needs of sick people.

SUMMARY

1. Some attitudes of patients toward surgery are discussed.

2. Some suggestions about the management of the preoperative interview are offered.

3. Some suggestions for the avoidance of psychic difficulties during the hospital stay and during convalescence are outlined.

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PLASTIC SURGERY IN MAMMOTH BREASTS

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THE indication for a nipple transplant mastopexy is gigantic enlargement of breasts that are physiologically nonfunctional. Other extenuating factors, such as age, general condition of the patient, and mental attitude toward the procedure, may affect the decision of the surgeon.

The operation is employed to relieve the patient of discomfort, enervation, pain, and in some cases semi-invalidism. It accomplishes cosmetic and physical improvement. The shape, size, and contour of the breasts are altered while the areola and nipple are retained. Although the latter will not function physiologically, feeling, nipple erection, and sensitiveness are regained. Little has been lost to the patient because the members were functionless prior to surgery.

In previous reports, we have presented a surgical technique for reconstructing enlarged breasts and retaining their physiologic function by a one-stage and a two-stage mastopexy, respectively.[2, 3] These techniques utilize reconstruction in conjunction with transposition of the nipple.

The purpose of this paper is to describe an operation for reconstructing mammoth enlargement of the breasts by means of transplanting the areola and nipple as a free graft in a one-stage operation. Previous reports of the mastopexy reconstruction with a nipple transplant have been described by Adams,[1] Lamont,[2, 3] Pickrell,[4] and Thorek.[5]

PREOPERATIVE PREPARATION

Study of the Patient.—Careful photographs are made for both record and study. Both lateral and front views with the patient erect, then bending forward, are taken (Fig. 3).

Laboratory studies necessary for any major procedure are made. The complete blood count, differential count, bleeding and clotting time, urinalysis, and complement fixation tests are studied. Other tests such as the basal metabolism rate, blood chemistry, etc., as may be necessitated by the specific case are carried out.

Often these patients are overweight and it is our policy to induce a weight loss by dieting prior to surgery and to continue such a regime after surgery. The reducing program is introduced gradually to allow the patient to retain her strength at the time of operation (Fig. 4).

It is well to explain the procedure in detail to the patient and it is often intelligent to place it in writing couched in simple terms understandable to the patient and her family.

Measurements and Markings.—Prior to surgery, careful measurements are made to indicate the lines of incision.

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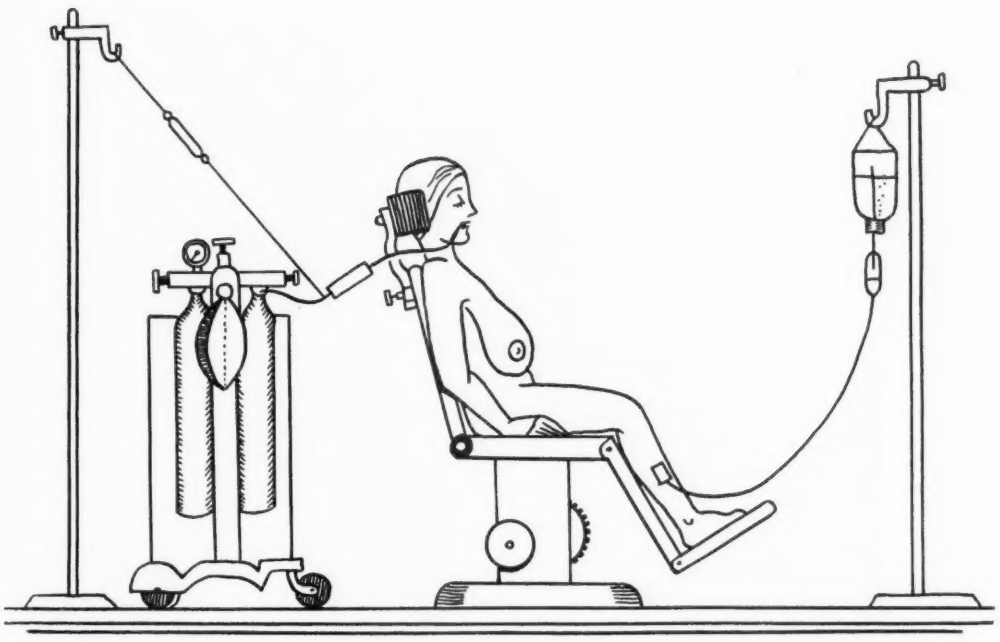

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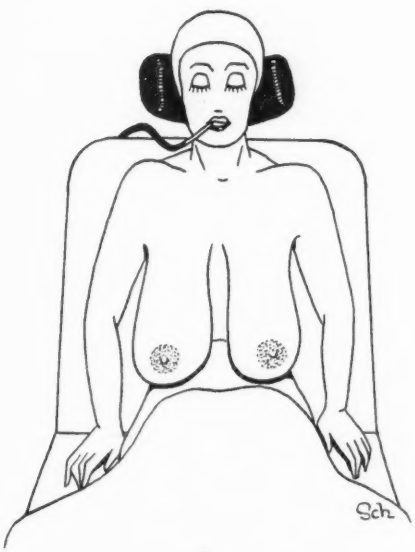
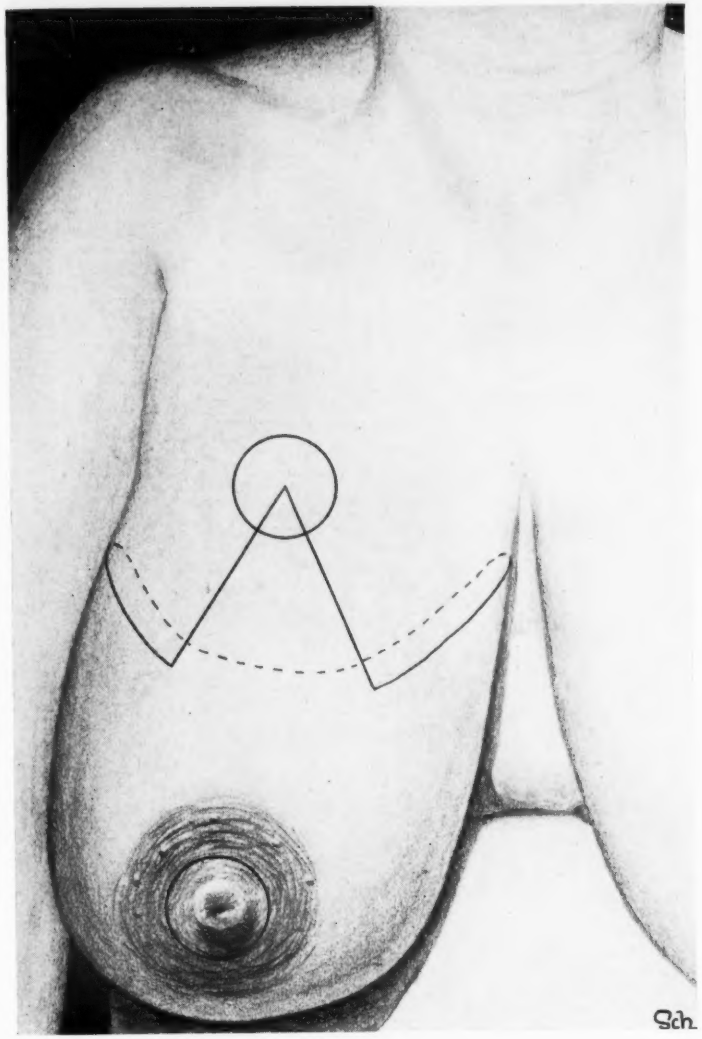


B.

Fig. 1.—*A*, Patient on the operating table in semi-setting position, with arms akimbo. This position allows for a more exact evaluation of the deformity during surgery. The anesthesia is endotracheal using cyclopropane. Fluids are given during surgery. *B*, Front view of patient in surgery. This semi-sitting position is maintained during the entire operation. By allowing the weight of the breasts to assert themselves, the surgeon is better able to judge the progress of the procedure.



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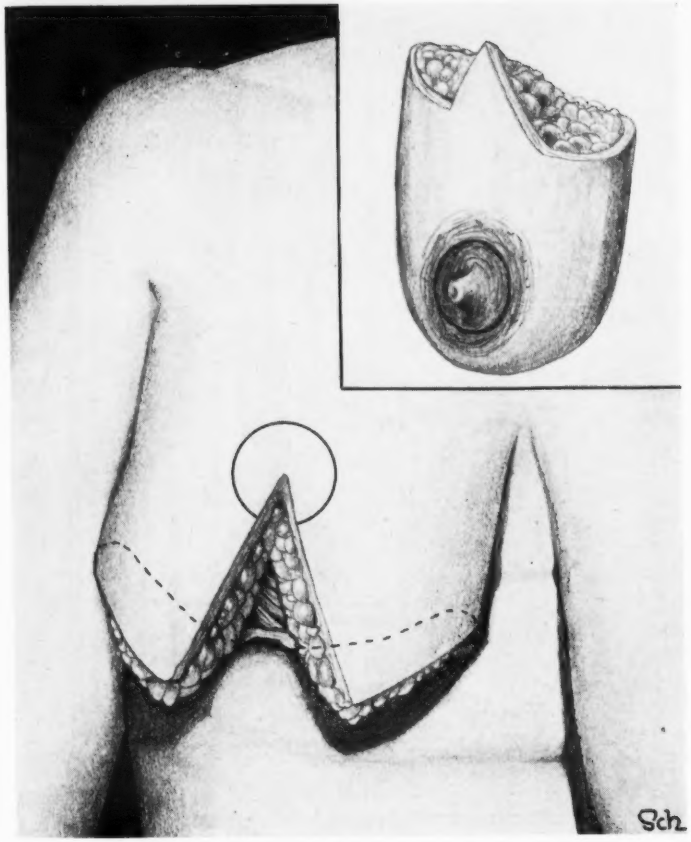
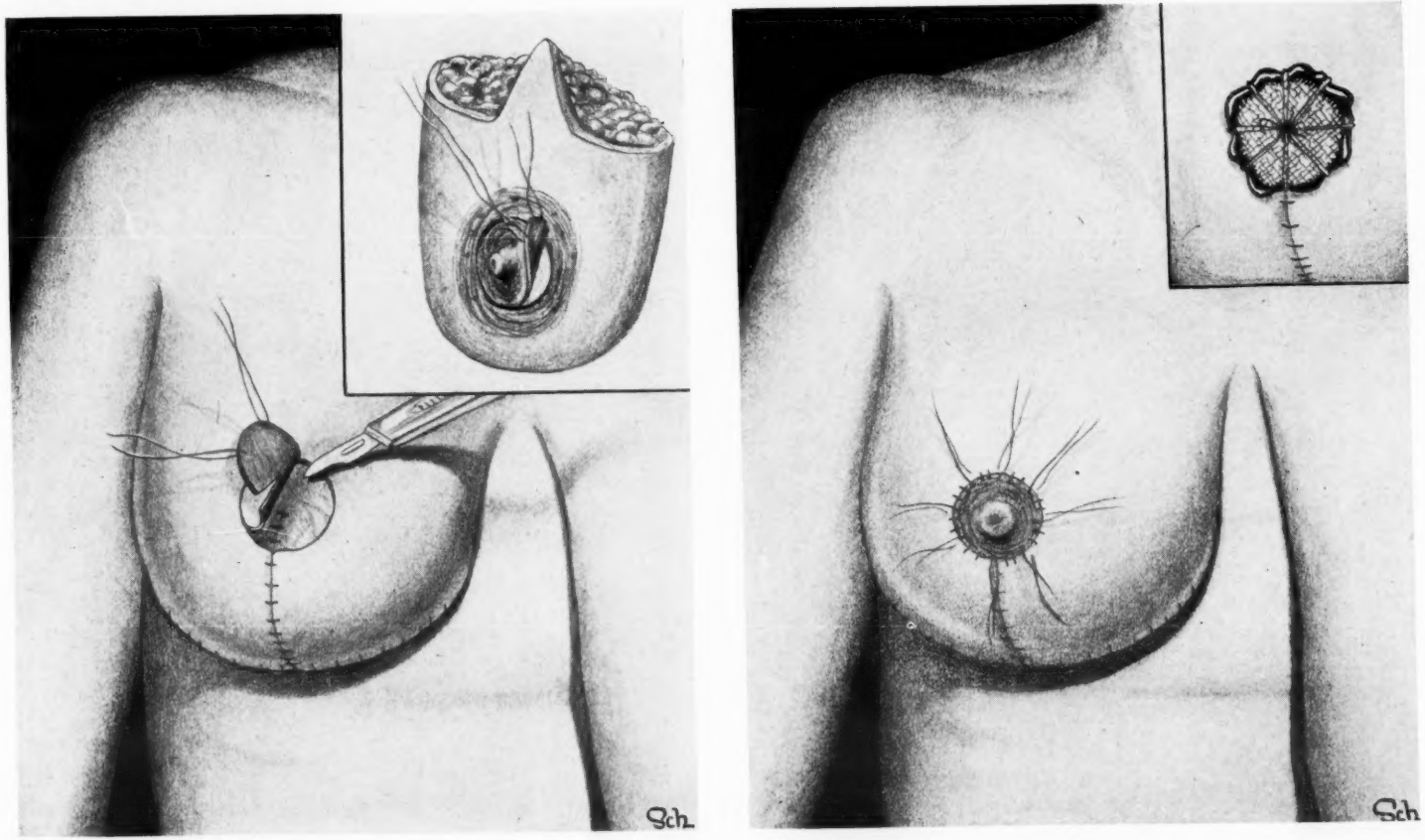


B.

Fig. 2, *A* and *B*.—*A*, The lines of incision are marked off with 3 per cent gentian violet, U.S.P. The position of the new areola site is arrived at, both by measurements and a preconception of the newly constructed breast. The dotted line is drawn 2 or 3 cm. above the patient's inframammary line, in that the latter has been pulled downward with time. *B*, The lower portion of the breast is resected in a block (see inset). The triangular resection of the lower pole allows for a shorter inframammary incision and the newly constructed breast is more shapely.

in a block (see inset). The triangular resection of the lower pole allows for a shorter inframammary incision and the newly constructed breast is more shapely.



C. *D.*

Fig. 2, *C* and *D.*—*C,* After all bleeders are meticulously controlled, the walls of the breast are approximated with 000 white silk sutures. The subcutaneous tissue is approximated with fine white silk 0000. The skin edges are united with black silk. At the new nipple site, a circle of full-thickness skin is resected. The areola with the attached nipple is similarly resected from the lower portion of the breast (see inset). *D,* The areola transplant is sutured into its new residence, employing both subcuticular and fine skin sutures. Several of the sutures are left long to obtain pressure over the areola graft, similar to a skin graft (see inset).

By holding the center of the breast and lifting the cephalic portion unward a conception of the new areola site may be gained by inspection.

Halving the distance between the acromial-clavicular joint and the olecranon process of the elbow and measuring downward on the chest from the center of the clavicle will aid in gauging the new nipple residence. The center of this point may serve as the peak of the reconstructed breast.

Initially a circle is drawn on the breast to indicate the position of the new areola site. This circle is somewhat larger than the final areola size, in that with the progress of the operation the lower portion of the circle is resected.

From the center of this circle, lines are marked off downward and laterally. The length of these lines will depend upon the size of the breast, the width of its base, and the amount of breast tissue present in the upper pole.

Lateral lines, made at an obtuse angle to the previous perpendicular ones, are carried to each side and meet a line drawn from side to side beneath the breast (approximately ¾ inches above the inframammary line). This latter marking is made above the inframammary line in that the weight of the breast over the years has pulled the normal position of this inframammary line downward. Thus by carrying it slightly higher, it will be hidden beneath the natural fold of the lower pole when the breast is reconstructed to a smaller size.

A circle is drawn on the areola around the nipple to indicate the size of the free transplant.

Anesthesia.—Endotracheal anesthesia with cyclopropane is usually employed. Intravenous fluids are begun as soon as the patient is asleep. On rare occasions blood plasma and whole blood are introduced.

Position on the Table.—The patient is placed in a semi-sitting position with the arms akimbo at the sides. Care should be taken to prevent undue pressure on the elbows and the ulnar nerve during the relatively long procedure (Fig. 1).

The patient in a sitting position offers a distinct advantage to the operator. The pendulousness of the breasts in this position allows a true evaluation as to their size and shape. Throughout the whole operative procedure, the surgeon is able to judge its developments. With the patient flat on the table and the heavy breasts falling to each side such a concept is usually most difficult.

SURGICAL PROCEDURE

Reconstruction of the Breasts.—The lines of incision are made along the previous markings. The lower pole of the breast, including the areola and nipple, is resected as a block. All bleeders are meticulously caught and tied with 00000 white silk (Fig. 2).

The remaining breast is then reconstructed. The two center walls are approximated with interrupted 000 white silk sutures. Along the inframammary line the breast tissue is sewn to the chest wall with interrupted 000 white silk sutures.

The skin is approximated subcutaneously with interrupted 0000 white silk sutures. The skin proper is sewn with interrupted 00000 black silk everting sutures. A Penrose drain is inserted at each corner of the inframammary incision.

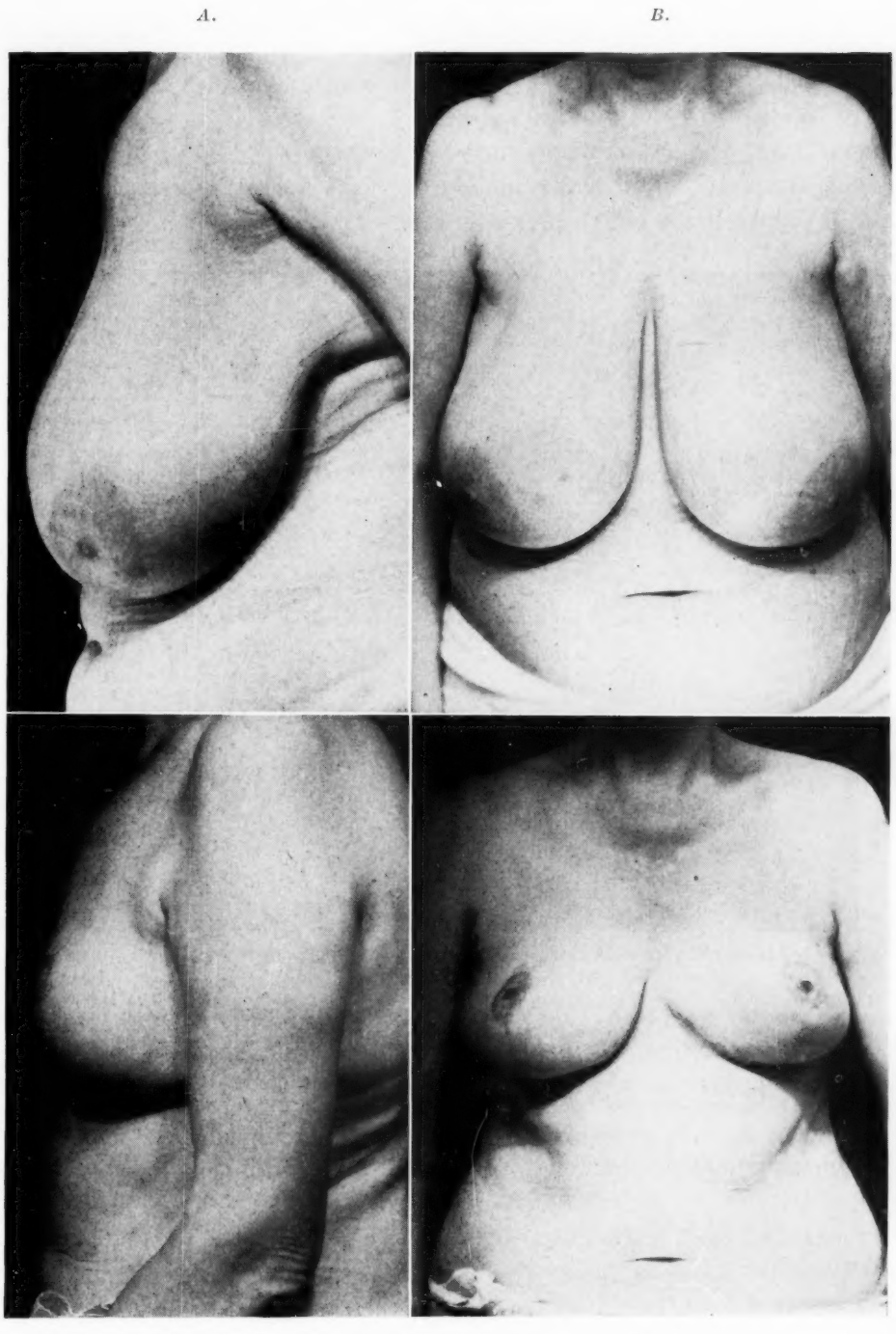
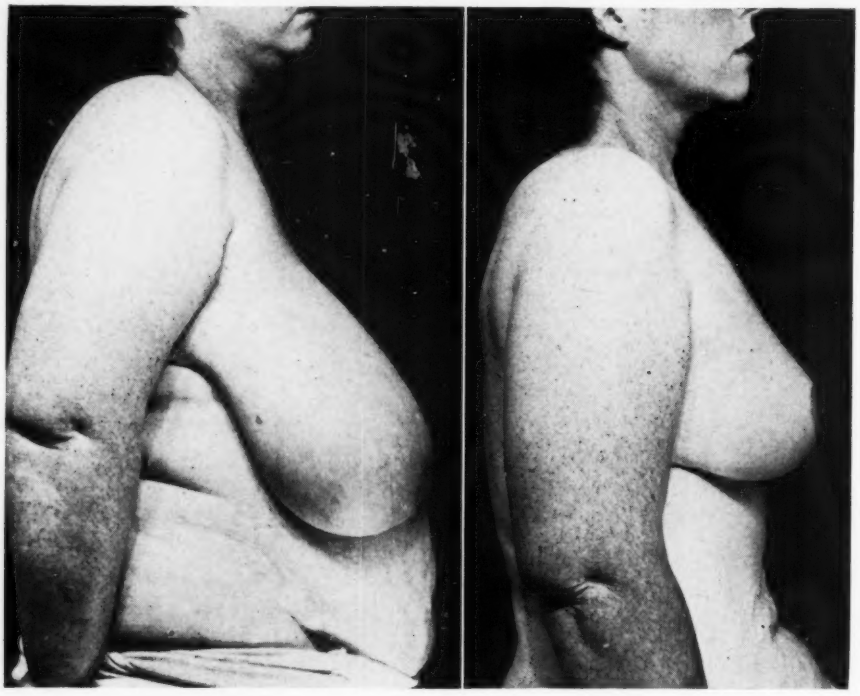


Fig. 3.—*A*, Markedly enlarged and pendulous breasts in a 60-year-old patient. The weight of the breasts had resulted in general enervation and nervousness. *B*, Age, size, and breasts that are physiologically nonfunctional are indications for a nipple transplant mastopexy. *C*, Four months following the surgery. *D*, Reconstruction of the breasts has resulted in generalized improvement of the patient's physical condition, and elimination of the poor posture and the deep "bra" marks on the shoulders.

Transplantation of the Areola and Nipple.—The circle of skin on the apex of the newly constructed breast is dissected off similar to cutting a full thickness graft. However, it is cut as thin as possible with the scalpel, so as to leave a "base" to accept the areola-nipple graft.

The areola including the nipple, previously circled, is dissected free as a full thickness graft. Again meticulous care is taken to gain this graft as thin as possible. The base of the nipple is carefully thinned.



A. *B.*

Fig. 4.—*A*, Mammoth nonfunctional breasts in a 45-year-old patient. The heavy breasts and excess weight of the patient had resulted in virtual invalidism. A diet regime was instituted with a weight loss of sixty pounds. *B*, Following a one-stage nipple transplant mastopexy.

After all bleeding has been controlled at the recipient site, the areola with the nipple is sewn into its new residence with interrupted 00000 silk sutures. Approximately eight of these sutures are left long to tie over the dressing for pressure.

Parresined mesh impregnated with petroleum jelly cut to circular size is placed over the areola-nipple graft. Several thicknesses of gauze cut to circular size are placed over the Parresined mesh. A circular piece of dental stent cut to fit the areola graft is placed over the gauze. (Mechanics' waste or sea sponge may be used in the place of stent.) The long silk sutures are tied over the dental stent.

The surgery on one breast is completed before a similar procedure is repeated on the second breast. Conscientious effort is made to gain bilateral symmetry of size, shape, and contour.

The surgical incisions forming the inverted "T" are dressed with Parresined mesh impregnated with petroleum jelly and overlaid with gauze flats. An abdominal pad is placed on each side over the gauze flats. A stockinet bandage is employed to hold the dressings in place and to gain reasonable pressure.

POSTOPERATIVE CARE

The Penrose drains are shortened on the second day. On the fourth day the drains are removed and a complete dressing is done on the breasts proper without disturbing the pressure dressings over the areola transplants.

The skin sutures uniting the inverted T incisions are removed on the sixth day and adhesive bridges are placed over the incisions. On the ninth day the pressure dressings over the grafts are removed and the silk sutures around the grafts are taken out. The grafted sites are redressed and moderate pressure is obtained. On the twelfth day the dressing is removed and adhesive bridges are continued over all incisions including the areola grafts for another ten days to two weeks.

The patient must avoid drastic exercise for one month postoperatively and though the convalescence is mild such advice will gain better scars and will deter the patient from interrupting the healing of tissues.

Though we have rarely found it necessary, a secondary excision of some scars may be done under local anesthesia one year later.

DISCUSSION

Reconstruction of the breasts with transposition of the nipple is preferable in all cases where it is desirous to retain their physiologic function. This procedure may usually be employed either as a one-stage or a two-stage mastopexy.

In selected cases where the breasts have gained a mammoth size and no longer have a functional role, the operation described in this paper may be elected.

The psychologic advantage to the patient of retaining the areola and nipple by a direct graft as compared to partial amputation of the breast without grafting the nipple will repay the plastic surgeon for his effort.

The T shaped incision is advantageous over the circular incision in amputating the lower portion of the breast. It allows for the reconstruction of a more pointed and shapely breast; it reduces the length of the inframammary incision.

CONCLUSION

A one-stage surgical procedure for reconstructing very large, nonfunctional breasts with a nipple transplant mastopexy has been presented. The indications for the operation, preoperative care, surgical method, and the postoperative course have been included.

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THE EFFECT OF ULTRAVIOLET RADIATION AND AIR CONDITIONING UPON THE AIR STERILITY IN A CLOSED SURGERY

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ONE of the major concerns in the operating suites of the modern hospitals of today is keeping the bacterial air-contamination as low as possible. Sterilization of the drapes; of the instruments, fixtures, walls, and floors is a reality of proved value, yet complete sterilization of the air in a surgery remains an accomplishment yet to be attained. The problem has become even more pressing with the addition of improved ventilation and air conditioning to the modern surgery. With modern air conditioning we are able to control high temperatures, as well as the great humidity which formerly discommoded the surgeon and dehydrated the patient. As a result we are now faced with a continuous changing of the air within the surgery; fresh, cool, outside air being introduced while the old air is being withdrawn by circulating fans. With this resultant constant circulation the possibility of contamination is increased, while both the quality and quantity of contamination vary with that of the outside air.

Disinfection of room air by ultraviolet radiation has been attempted in many different ways. Experiments by Luckiesh[1, 2] have shown that the maximum bactericidal effect of ultraviolet radiation was obtained with a wave length of 2,537 Angström units. This was demonstrated by exposing *Escherichia coli* to varying ultraviolet wave lengths. Sunlight loses its short wave radiant content by filtration through the earth's atmosphere, particularly through its ozone. Therefore, the most valuable germicidal rays of the sun do not reach us in sufficient quantity to be useful. Consequently, it becomes necessary to resort to some artificial means of air disinfection.[3] This becomes a consideration of fundamental importance in extending the asepsis in an operating room.

The opposite extreme, an overdosage of the germicidal ultraviolet wave length, must also be avoided, since it has both harmful and deleterious effects upon the body when this occurs from unlimited and unprotected exposure to the light.[4] To obviate this danger, the Council on Physical Medicine of the American Medical Association[5] has noted that the quantity of radiation in a closed room should be so regulated that the amount of ozone near any occupant of such a room will not exceed one part in ten million. A properly designed mercury vapor germicidal ultraviolet lamp will radiate less than 5 per cent of other wave lengths than the desired one of 2,537 Angström units. Selection of the lamp must therefore be done with care and understanding of its function, and its placement accomplished with observance to the exposure permitted to occupants of the room being irradiated.[6, 7]

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Continued ultraviolet radiation has been proposed as a means of diminishing the amount of contamination in the air in operating rooms of many hospitals.[3] To determine the effect of ultraviolet radiation and air conditioning upon the sterility of the air in a closed surgery under fixed conditions, an investigation was conducted at the Franklin County Tuberculosis Hospital as a joint project of the Hospital and the Department of Research Surgery of The Ohio State University.

Studies were made on the sterility of the air within a closed operating room 15 by 24 feet with no windows opening to the outside. Seven feet above the floor on the sidewalls were located two ultraviolet sterilizing units utilizing mercury vapor tubes for producing the radiation of 2,537 Angström units. On the wall just above one of these units was the opening for the air-conditioning unit, a screen grid 17½ inches wide by 8 inches high. In the center of the operating room was located the operating table over which a standard operating room light was suspended (Fig. 1).

The experiment was divided into four parts. The *first* part (Condition I) was carried out with the air-conditioning unit sealed off by means of waxed paper and adhesive tape and the ultraviolet lights turned off for twenty-four hours previous to and during the experiment. The *second* portion (Condition II) was conducted with the ultraviolet lights off twenty-four hours previous to and during the experiment but with the air-conditioning unit in operation. The *third* portion (Condition III) was conducted with the ultraviolet lights on for twenty-four hours previous to and during the experiment and the air conditioning off. The *fourth* portion (Condition IV) was conducted with the ultraviolet lights on for twenty-four hours previous to and during the experiment and the air-conditioning unit in operation.

Using blood agar plates as media for the culture of bacteria and molds in the air, after a major surgical procedure had begun, eight Petri dishes were placed in positions as shown in Fig. 1. Some of the plates were placed on the floor and others at table level. They were exposed for thirty minutes after which they were covered and removed from the operating room. This procedure was repeated for each of the conditions described. In every case all doors opening into the surgery were closed for a period of at least forty minutes prior to beginning the study. All drapes were in place, and the operation was well under way before the agar plates were uncovered. No person entered or left the operating room during these studies, and anyone who entered within two hours prior to these studies wore mask and cap to minimize contamination from head, throat, and mouth.

From these observations the tabulated results as shown in the accompanying charts were obtained (Tables I to IV).

Consideration of the tables emphasizes the fact that the total colonies are highest with the air conditioner in operation. They are only slightly influenced by ultraviolet radiation, since with the lights off the total growth is 271 colonies after seventy-two hours, while with the ultraviolet lights on there were even slightly greater numbers of colonies (294) after seventy-two hours. There does not seem to be any marked difference in the distribution of contaminants by the

action of the air conditioner, since the total per cent of growth at table level and floor level does not vary greatly.

From a casual glance at the results of this study, it would seem that under ideal conditions (Table IV) with the ultraviolet lights and air conditioner in operation, the most disturbing results were obtained, since the total colonies are as high or higher than the number obtained with the air conditioner on and the ultraviolet lights off (Table II).

However, when the last column of the table is studied it will be seen that in Condition II (Table II) in which the air conditioner was in operation without

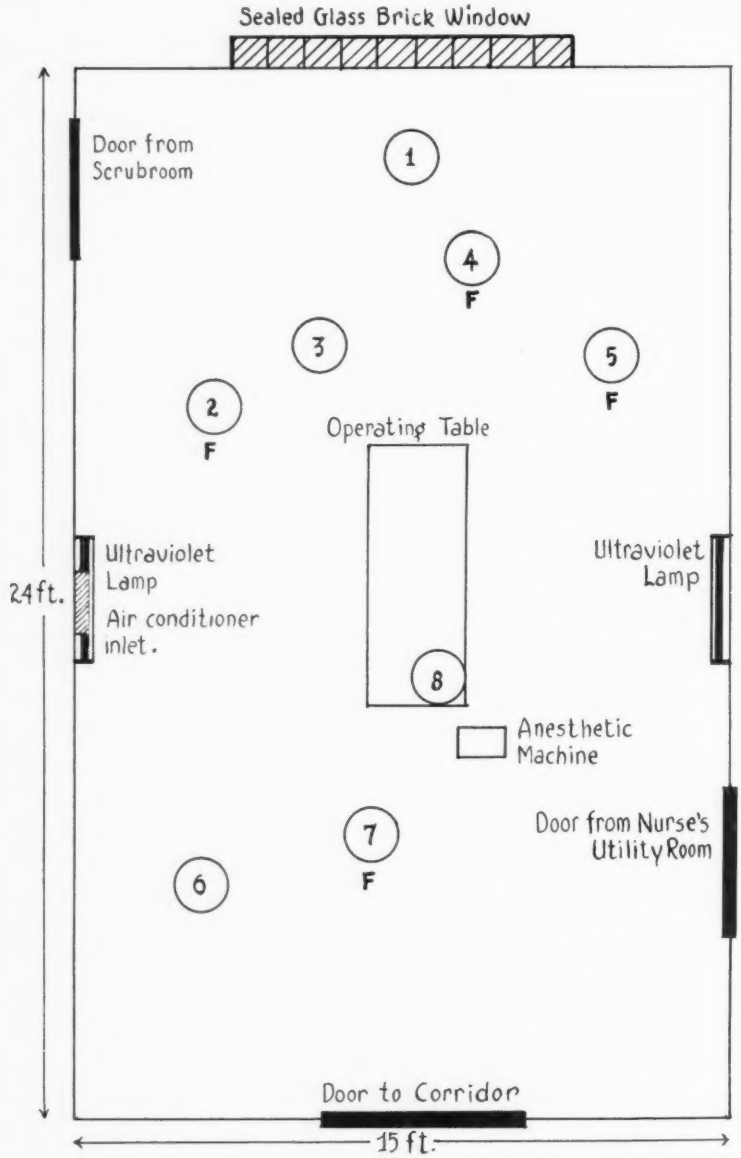

Fig. 1.—Diagram of surgery and Petri dish placement. *F* below figure indicates that Petri dish was on the floor. Scale: ⅔ inch = 3 feet.

TABLE I. TYPES AND PERCENTAGES OF BACTERIAL CONTAMINANTS

Condition I. Air Conditioner Sealed Off and Ultraviolet Lights Off Twenty-four Hours Before and During Surgery (Eight Plates Exposed)

TOTAL COLONIES			NUMBER OF COLONIES OF EACH TYPE AND PER CENT OF TOTAL GROWTH								
HOURS AFTER EXPOSURE			HOURS AFTER EXPOSURE								
24	48	72	24			48			72		
			COCCI	MOLDS	GRAM + BACILLI	COCCI	MOLDS	GRAM + BACILLI	COCCI	MOLDS	GRAM + BACILLI
150	228	231	135 (90%)	0 (0%)	14 (10%)	150 (76%)	48 (15%)	30 (9%)	150 (65%)	51 (23%)	30 (12%)

Total per cent growth at table level 45%
Total per cent growth at floor level 55%

CLASSIFICATION PERCENTAGE						
COCCI (71%)				GRAM + BACILLI (12%)		MOLDS (17%)
STAPH. ALBUS	STAPH. AUREUS	STAPH. CITREUS	SARCINA LUTEA	B. SUBTILIS	B. MYCOIDES	UNCLASSIFIED
53%	.5%	1%	16.5%	9.5%	2.5%	17%
Skin contaminants 71%				Air contaminants 29%		

the ultraviolet lights, the air contaminants, *Bacillus subtilis* and *Bacillus mycoides*, are present in much greater numbers (29 per cent) than in Condition IV (Table IV) with the air conditioner and ultraviolet lights both in operation (8.5 per cent). This is also true of the unclassified contaminants where, with only the conditioner in operation they represented 11 per cent of the total colonies while in the presence of ultraviolet radiation they dropped to 6.5 per cent.

In every instance operating the air conditioner increased the gram-positive organisms and molds, which represent air contaminants. The effect of the ultraviolet radiation is easily demonstrated by comparison of the results of Condition I (Table I) with the air conditioner inlet sealed off and the ultraviolet lights

TABLE II. TYPES AND PERCENTAGES OF BACTERIAL CONTAMINANTS

Condition II. Air Conditioner in Operation and Ultraviolet Lights Off Twenty-four Hours Before and During Study (Eight Plates Exposed)

TOTAL COLONIES			NUMBER OF COLONIES OF EACH TYPE AND PER CENT OF TOTAL GROWTH								
HOURS AFTER EXPOSURE			HOURS AFTER EXPOSURE								
24	48	72	24			48			72		
			COCCI	MOLDS	GRAM + BACILLI	COCCI	MOLDS	GRAM + BACILLI	COCCI	MOLDS	GRAM + BACILLI
209	230	271	142 (67%)	0 (0%)	67 (33%)	148 (64%)	13 (5.5%)	69 (30.5%)	158 (58)%	39 (15%)	74 (27%)

Total per cent growth at table level 44%
Total per cent growth at floor level 56%

CLASSIFICATION PERCENTAGE						
COCCI (60%)				GRAM + BACILLI (29%)		MOLDS (11%)
STAPH. ALBUS	STAPH. AUREUS	STAPH. CITREUS	SARCINA LUTEA	B. SUBTILIS	B. MYCOIDES	UNCLASSIFIED
39%	.7%	1.3%	19%	19%	10%	11%
Skin contaminants 60%				Air contaminants 40%		

TABLE III. TYPES AND PERCENTAGES OF BACTERIAL CONTAMINANTS

Condition III. Air Conditioner Sealed Off and Ultraviolet Lights on Twenty-four Hours Before and During Study (Eight Plates Exposed)

TOTAL COLONIES			NUMBER OF COLONIES OF EACH TYPE AND PER CENT OF TOTAL GROWTH								
HOURS AFTER EXPOSURE			HOURS AFTER EXPOSURE								
24	48	72	24			48			72		
90	160	195	COCCI	MOLDS	GRAM + BACILLI	COCCI	MOLDS	GRAM + BACILLI	COCCI	MOLDS	GRAM + BACILLI
			79 (87%)	0 (0%)	11 (13%)	99 (62%)	19 (30%)	12 (8%)	148 (75%)	26 (13%)	21 (12%)

Total per cent growth at table level 46%
Total per cent growth at floor level 54%

CLASSIFICATION PERCENTAGE						
COCCI (78%)				GRAM + BACILLI (10.5%)		MOLD (11.5%)
STAPH. ALBUS	STAPH. AUREUS	STAPH. CITREUS	SARCINA LUTEA	B. SUBTILIS	B. MYCOIDES	UNCLASSIFIED
49%	1%	6%	22%	8%	2.5%	11.5%
Skin contaminants 78%				Air contaminants 22%		

kept off with Condition III (Table III) with the air conditioner inlet sealed off and the ultraviolet lights turned on. Here it is seen that the utilization of the ultraviolet radiation caused a reduction in the air contaminants from 29 per cent to 22 per cent.

The cocci representing skin contaminants are found to be highest with the ultraviolet lights and air conditioner on as in Condition IV (Table IV), and the lowest with the air conditioner on and the ultraviolet lights off, as in Condition II (Table II). This may seem slightly incongruous, but since the counts were made on a total plate number, an increase in any fraction or class on the plate would necessitate a reduction in another fraction or class. Since in Condition II

TABLE IV. TYPES AND PERCENTAGES OF BACTERIAL CONTAMINANTS

Condition IV. Air Conditioner in Operation and Ultraviolet Lights on Twenty-four Hours Before and During Study (Eight Plates Exposed)

TOTAL COLONIES			NUMBER OF COLONIES OF EACH TYPE AND PER CENT OF TOTAL GROWTH								
HOURS AFTER EXPOSURE			HOURS AFTER EXPOSURE								
24	48	72	24			48			72		
203	277	294	COCCI	MOLDS	GRAM + BACILLI	COCCI	MOLDS	GRAM + BACILLI	COCCI	MOLDS	GRAM + BACILLI
			183 (90%)	0 (0%)	20 (10%)	236 (85%)	18 (6%)	23 (9%)	245 (83%)	24 (8%)	25 (9%)

Total per cent growth at table level 49.8%
Total per cent growth at floor level 50.2%

CLASSIFICATION PERCENTAGE						
COCCI (85%)				GRAM + BACILLUS (8.5%)		MOLD (6.5%)
STAPH. ALBUS	STAPH. AUREUS	STAPH. CITREUS	SARCINA LUTEA	B. SUBTILIS	B. MYCOIDES	UNCLASSIFIED
52%	1%	3%	29%	6.5%	2%	6.5%
Skin contaminants 85%				Air contaminants 15%		

(Table II) the air contaminants are so markedly increased (40 per cent of the total plate count), it is consequently accompanied by a reduction of the cocci group to 60 per cent; whereas in Condition IV (Table IV) with a reduction of air contaminators to 15 per cent, the cocci are more abundantly found and represent 85 per cent of the plate count. As the study was directed at the sterility of the air, the skin contaminants are not significant except for the portion of the total plate count which they represent. The significant conclusions can be seen by comparison of Table I in which there were 29 per cent air contaminants with Table III where the addition of ultraviolet lights decreased the air contaminants to 22 per cent. Again, in Table II the 40 per cent air contaminants was lowered to 15 per cent when ultraviolet radiation was superimposed (Table IV). In Table I, 29 per cent of the air contaminants increased to 40 per cent (Table II) by simply turning on the air-conditioning machine. There was also an increase in bacterial contaminants rather than molds.

SUMMARY

1. Studies were made in a closed surgery to determine the efficacy of ultraviolet radiation upon the sterility of the air, and the contamination produced by operation of an air-conditioning unit ventilating the room through a small screen grid 17½ by 8 inches, located 7 feet above the floor in the middle of one of the side walls just above an ultraviolet lamp.

2. Studies of the degree of contamination at floor level and at operating-table level were made. Classification of air and skin contaminants as well as of molds was made and the resultant percentages tabulated.

CONCLUSION

Air conditioning without any means of filtering the inlet increases the air contamination in a closed room. The contamination at various levels in a room is not appreciably affected by air conditioning. Ultraviolet radiation in a closed room exerts a beneficial effect on the relative sterility of the air by reducing the quantity of air contaminants equally at all levels. It is possible that by a finer screening device, or by the use of ionization further to cleanse the air before it is injected into a room, the contamination might be still further lessened.

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A COMPARISON OF SOLID AND LIQUID SOAP AS VEHICLES FOR G-11 (HEXACHLOROPHENE) IN THE SURGICAL WASH

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PREVIOUS studies on the reduction of skin bacteria by the compound G-11 (hexachlorophene) incorporated in soap have indicated the effectiveness of the compound in the preparation of the surgeon's hands.[1, 2, 3] Both solid and liquid soaps have been used in these studies; this communication presents evidence that the two vehicles for the agent are not equally effective. Simulated as well as actual surgical operating conditions have been employed in the comparison. In addition, data are presented showing that, with very little loss of effectiveness, the time of application can be less than the six minutes previously suggested. Attempts to shorten the time of application were made because of drying and minor irritation of the skin in about one-half the individuals using the six-minute contact. In addition to these studies, a note on the employment of hexachlorophene to prepare the skin of the operative site is included.

MATERIALS AND METHODS

The solid soap contained 2 per cent hexachlorophene, the liquid soap contained 1 per cent in a 20 per cent solution of potash soap.‡ The gel preparation consisted of 5 per cent Ivory soap and 1 per cent hexachlorophene§ dissolved in hot distilled water and allowed to stand until a semisolid gel formed. This was scooped up and applied in the same way as the liquid preparation. The procedure employed in the six-minute contact period was as previously described,[3] consisting of two three-minute applications with a tap water rinse after each application, followed by a rinse of 1:1000 aqueous Zephiran. The nails were cleaned during the first three-minute interval; no brush was used. In the studies on bar soap containing 2 per cent hexachlorophene the same time intervals were used and the individual applied soap long enough to obtain a good lather.

Skin counts were carried out by a modification of Price's[4, 5] method. The gloves were removed and the hands moistened to a point one inch above the wrist in one liter of sterile distilled water in a sterile basin. Ivory soap was lathered into the skin for 25 seconds; the soap was then laid aside and the lather massaged into the hands for 75 seconds. This was then rinsed into the basin for 25 seconds. Samples of 0.1 and 1.0 ml. were plated in nutrient agar with the addition of 0.1 ml. of sterile sheep serum to each plate to inhibit antiseptic carried over with the rinse water. Counts were made after forty-eight hours at 37° C., and expressed as numbers of organisms per liter of wash water. If the 1 ml. sample showed no organisms, it was recorded as less than 1000 organisms per liter.

RESULTS

In each procedure examined, a group of persons was tested first under simulated operating conditions. These individuals all wore gloves for forty-five

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§Obtained from Dr. W. Gump, Givaudan-Delawanna, Inc., Delawanna, N. J.

minutes between the application of the given procedure and the testing of the skin. In the group of surgeons and nurses examined there was necessarily considerable variation of conditions, the major one involving the time interval in gloves. Another variable was introduced in the occasional glove changes required during operations, and still another in the varying amount of manual activity of the different individuals. In spite of this the results are fairly consistent for the latter group. The variations are indicated in each case whenever they occurred. In all the tables any individual who wore gloves for only ¾ hour represents a test under simulated operating conditions; all longer periods in gloves represent individuals under actual operation conditions. Each person retains the same designating letter throughout.

In evaluating the solid soap containing 2 per cent hexachlorophene, it was compared with 1 per cent hexachlorophene in 5 per cent Ivory soap gel rather than in a liquid potash soap solution for two reasons. First, it was desirable to retain the same type of sodium soap and vary only the total volume applied to the skin. Also, it was desired to determine which type of soap caused more dryness or reddening of the skin during the six-minute contact periods.

Tables I, II, and III show the results of the conventional ten-minute scrub with a brush, the 2 per cent hexachlorophene (G-11) solid soap, and the 1 per cent soap gel, respectively. Examination of the averages as well as the individual counts shows that the solid soap (Table II) reduces counts by tenfold although in two instances (N and P) the counts are higher than those shown in Table I; the much greater effect of the soap gel with 1 per cent hexachlorophene appears in Table III.

TABLE I. EFFECT OF A TEN-MINUTE SURGICAL SCRUB WITH BRUSH FOLLOWED BY A 70 PER CENT ALCOHOL RINSE*

INDIVIDUAL	HOURS IN GLOVES	GLOVE CHANGES	ORGANISMS PER LITER OF WASH WATER
L†	3	1, after 2 hr.	11,220,000
M	3½	1, after 2½ hr.	3,760,000
N	4	1, after 2 hr.	1,860,000
P	4	1, after 2 hr.	1,900,000
O	3	None	78,000
Q	2½	None	67,000
R	2	Four times	4,700,000
Average			3,369,000

*No hexachlorophene (G-11) used. Three minute scrub with 70 per cent alcohol rinse between glove changes. Counts made at end of operation.

†In this and subsequent tests, subject "L" wore cotton gloves under rubber gloves.

Since there were more complaints of skin irritation from persons using the soap gel than from those using the 20 per cent potash liquid soap preparation, we returned to the latter material and reduced the time of contact to one minute. The results are compiled in Table IV and indicate that this time may be substituted for the six-minute period. Although the average is higher than in Table III, inspection of the individual counts shows that this average has been affected by three unusually high counts (M, P, and R), the remaining twelve being satisfactory. There has been no evidence of irritation from the one-minute contact with the exception of one surgeon who washed three times in one six-hour period

TABLE II. EFFECT OF SIX-MINUTE CONTACT WITH 2 PER CENT HEXACHLOROPHENE SOLID SOAP WITH AQUEOUS ZEPHIRAN 1:1000 RINSE*

INDIVIDUAL	HOURS IN GLOVES	GLOVE CHANGES	NO. OF CONSECUTIVE DAYS' HEXACHLOROPHENE CONTACT INCLUDING DAY OF TEST	ORGANISMS PER LITER OF WASH WATER
A	¾	None	3	450,000
B				360,000
C				140,000
D				73,000
E				89,000
F				871,000
G				117,000
H				440,000
I				183,000
J				60,000
K				56,000
L	3	1, after 2 hr.	3	330,000
M	2½	None	4	2,260,000
N	4½	1, after 3½ hr.	2	2,830,000
O	4½	1, after 3½ hr.	2	30,000
P	3	None	2	680,000
Q	2½	None	2	70,000
Average				531,000

*One-minute hexachlorophene wash between glove change.

TABLE III. EFFECT OF A SIX-MINUTE CONTACT WITH 1 PER CENT HEXACHLOROPHENE IN SEMI-SOLID IVORY SOAP (5%) GEL.*

INDIVIDUAL	HOURS IN GLOVES	GLOVE CHANGES	NO. OF CONSECUTIVE DAYS' HEXACHLOROPHENE CONTACT INCLUDING DAY OF TEST	ORGANISMS PER LITER OF WASH WATER
J	¾	None	3	2,000
L	3½	1, after 2 hr.	3	10,000
M	2¾	None	2	63,000
N	2½	None	3	3,000
O	2¾	None	2	4,000
P	3½	1, after ¾ hr.	2	5,000
Q	2¾	None	3	1,000
Average				12,500

*One-minute hexachlorophene wash between glove changes.

and noted some reddening and roughening of the skin. She stated that this was not as marked as three ten-minute scrubs with a brush would produce in the same interval. The surgeons and nurses employing the one-minute contact period have used three different methods of application. One consists of the spreading of liquid soap on the dry skin, the nails being previously cleaned. Another involves wetting the hands and arms in tap water followed by a similar application of hexachlorophene soap; the nails are cleaned during the one-minute contact period. The third method, which would appear to be the most satisfactory, consists of washing the hands and arms with ordinary soap, cleaning the nails during this process. After a tap water rinse, the liquid hexachlorophene soap is applied for one minute. All three methods should be followed by a very thorough tap water rinse and a 1:1000 aqueous Zephiran rinse

before drying on a sterile towel. There appears to be no significant difference in the counts following any of the three methods.

The persistence of the activity of hexachlorophene over extended periods of use, from one to three months, was determined in six individuals who had been using the material under surgical operating conditions three to four days per week. Table V shows that the effect is maintained over this period, with no indication of the development of hexachlorophene-resistant flora in the skin. As in Table IV, the average is raised by two high counts in the small number of individuals available. Furthermore, a repeat count on subject L one week later, all other conditions being the same, showed only 4,000 organisms per liter.

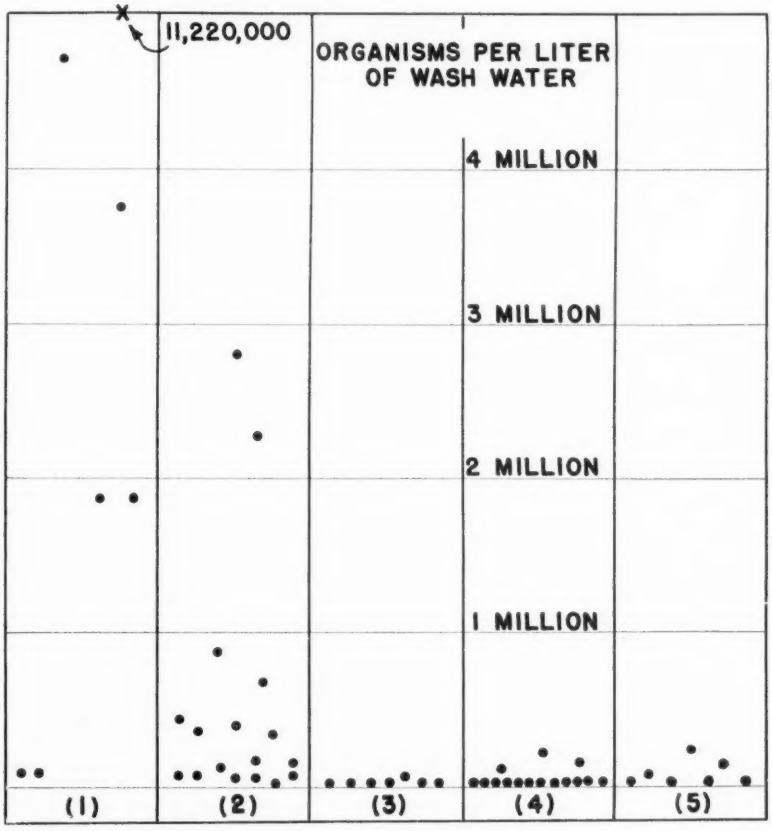

Fig. 1.—Summary of Tables I to V. (*1*) Ten-minute scrub without hexachlorophene, (*2*) six-minute hexachlorophene in solid soap, (*3*) six-minute hexachlorophene in soap gel, (*4*) one-minute hexachlorophene in liquid soap, (*5*) same as (*4*) after one to three months' use.

The material has been used in the surgical preparation of the skin of more than fifty patients, twenty-four and forty-eight hours before operation. Skin biopsies have been studied from several cases as well as from patients subjected to a standard skin preparation with iodine, ether, and alcohol, with no observed differences. No gross evidence of skin irritation or delay in healing has been seen, but it should be emphasized that the material must be rinsed off the skin thoroughly after each application to avoid irritation.

TABLE IV. EFFECT OF A ONE-MINUTE CONTACT WITH 1 PER CENT HEXACHLOROPHENE LIQUID SOAP WITH AQUEOUS ZEPHIRAN 1:1000 RINSE*

INDIVIDUAL	HOURS IN GLOVES	NO. OF CONSECUTIVE DAYS' HEXACHLOROPHENE CONTACT INCLUDING DAY OF TEST	ORGANISMS PER LITER OF WASH WATER
A	¾	3	3,000
C	¾	3	2,000
G	¾	3	3,000
I	¾	3	11,000
S	¾	3	3,000
T	¾	3	7,000
L	2½	2	Less than 1,000
M	1½	2	230,000
P	3	2	130,000
Q	2½	2	2,000
R	2½	2	84,000
U	2	2	1,000
V	2	2	1,000
W	2	2	3,000
X	2½	2	Less than 1,000
Average			32,000

*No glove changes except subject R who changed twice.

TABLE V. EFFECT OF ONE TO THREE MONTHS USE OF 1 PER CENT HEXACHLOROPHENE IN LIQUID SOAP, WITH A ONE-MINUTE CONTACT PERIOD*

INDIVIDUAL	NUMBER OF MONTHS OF HEXACHLOROPHENE USE	HOURS IN GLOVES	ORGANISMS PER LITER OF WASH WATER
L	3	1¼	232,000
M	3	3	146,000
P	3	3¾	50,000
Q	3	1½	15,000
U	1	1¾	Less than 1,000
V	1	1½	17,000
Average			77,000

*No glove changes; tests made on second consecutive day of contact.

DISCUSSION

The greater effectiveness of hexachlorophene (G-11) when it is incorporated in a liquid soap rather than a solid soap vehicle is probably due to the much larger amount of the material applied to the skin in the liquid form. It is not due to the superiority of a potash over a sodium soap since a semisolid 5 per cent sodium soap gel was as effective as a 20 per cent potash soap solution. This is substantiated by experiments dealing with the recovery of hexachlorophene from the skin after varying periods of time.[6]

The reduction in contact time from six minutes to one minute is associated with some increase in the average organism count of the skin, but in view of the occasional erratic counts obtained in this type of study and also in view of the fact that certain individuals tend to have abnormally high numbers of skin bacteria, the average count presented in this case may be open to suspicion. For example, in Table IV, showing the reduction of skin organisms by a one-minute contact period, twelve out of fifteen counts are extremely low, the average being

raised by counts from only three individuals. In the high average of the counts obtained after contact with solid soap (Table II) this is not the case, since inspection of the individual counts from which the average was calculated shows a uniformly high level.

Based on the data presented here, the recommended surgical wash is as follows:

1. The hands and arms are washed (not scrubbed) with ordinary toilet or green soap for one minute or more, and the nails are cleaned. A tap water rinse is used.
2. A large palmful of 1 per cent hexachlorophene in 20 per cent potash soap solution is applied to each hand and arm and a lather is developed. The total time of contact is one minute (or more) followed by a very thorough tap water rinse.
3. The hands and arms are immersed in aqueous Zephiran 1:1000 for a few seconds and dried on a sterile towel.

The suggested procedure for the preparation of the patient's skin is most effective when started forty-eight hours before operation. If this is not possible, preparation twenty-four hours preoperatively or on the day of operation will still effect a reduction of the skin flora, but to a progressively lesser degree. The following wash is carried out forty-eight and twenty-four hours before operation and also on the day of the operation, as soon before incision as is practicable, giving a total of three contacts.

1. The area to be prepared is wet with tap water, and 5 to 10 ml. (depending on the area) of 1 per cent hexachlorophene in 20 per cent potash soap solution are poured on and worked up to a lather with a gauze sponge. This is allowed to remain for five minutes followed by a tap water rinse. In preparation of the scalp this is carried out as a shampoo in which case a larger volume of soap (10 to 20 ml.) is necessary. The same five-minute contact time is used here. The prepared area need not be covered with a dressing.
2. This is repeated two or three times, at daily intervals, including the day of operation.
3. Prior to incision a strong skin disinfectant such as iodine is applied as usual to destroy superficial organisms.

SUMMARY

1. The effectiveness of hexachlorophene (G-11) in reducing skin organisms in the preparation of the hands for surgery is considerably greater when the agent is incorporated in a liquid soap, than when it is used in a solid soap.

2. The time of contact may be reduced to one minute in the surgical wash.

3. Hexachlorophene has been used in the preparation of the skin of more than fifty surgical patients with no evidence of irritation or delay in healing.

4. Detailed procedures for the preparation of the surgeon's and the patient's skin with hexachlorophene are presented.

The authors wish to express their appreciation to the doctors, nurses, and students who cooperated in the testing of these materials.

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Surgical Technique

INTUSSUSCEPTED CONICAL VALVE FORMATION IN JEJUNOSTOMIES

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IF THERE is a local recurrence after a radical operation for malignant disease in the esophagus or after total gastrectomy, it may be exceedingly difficult or impossible to feed the patient. If the stomach is displaced into the thoracic cavity as a result of high esophagogastrostomy, or if it is absent after total gastrectomy, the excellent Janeway-Spivack type of gastrostomy cannot be appplied for feeding purposes. Feeding must be accomplished through a jejunostomy. Although the Witzel type of jejunostomy is quite satisfactory for temporary use, it should not be employed as a permanent stoma. It will not stay patent and will leak and cause discomfort with painful, burning excoriations which inevitably develop from escaping digestive fluids issuing from the stoma. A "leakproof" jejunostomy is needed, one which permits the introduction of food and yet prevents seepage, spilling, and regurgitation.

For this purpose a modification of the Maydl* type of jejunostomy is suggested, with an intussuscepted conical valve in the "intake segment."

TECHNIQUE

1. Divide jejunum at a high level; anastomose the proximal end into the side of the lower segment leaving a 6 inch long stump in obese, and a 5 inch long stump in thin individuals.

2. Place an Allis forceps 1½ inches above the anastomosis in each of the four quadrants of the bowel stump.

3. Place a seromuscular silk purse-string suture around the jejunal stump about 1½ inches above the level of the Allis forceps. Avoid vessels entering intestinal wall on the mesenteric side.

4. Introduce a No. 16 or No. 18 rubber catheter with a cuff about 4 inches from its tip through the open end of the stump. Guide tip of catheter several inches distalward beyond the anastomosis and tie the purse string in such a manner that it will engage the catheter within the lumen just below the cuff. While steadying the bowel with the Allis forceps, intussuscept the stump with the help of the catheter for 1 to 1½ inches, creating an inverted cone, the tip of which is the purse string tied around the catheter.

5. Hold inverted stump in this position, place interrupted seromuscular silk stitches along the external contact-fold of the intussusception so that each suture will anchor the serosa of the "entering part" to the marginal serosa of the "intussuscipiens."

6. Deliver jejunal stump through stab incision made at an optional point of the abdominal wall; secure it to the latter with several stitches; close mesenteric rents to prevent strangulation.

When operation is completed, the intussuscepted portion of the jejunal stump forms an inverted cone with its tip directed inward. It will function

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*Maydl, K.: Ueber eine neue Methode zur Ausfuhrung der Jejunostomie und Gastroenterostomie, Wien. med. Wchnschr. 42: 697-741, 1892.

Fig. 1.

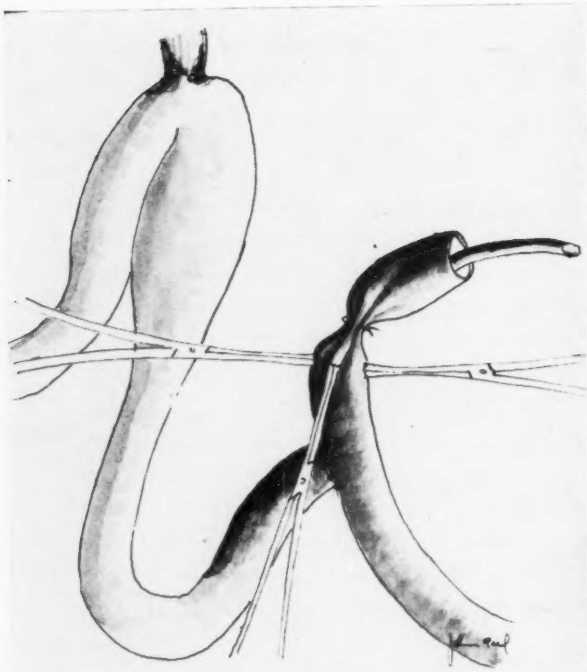
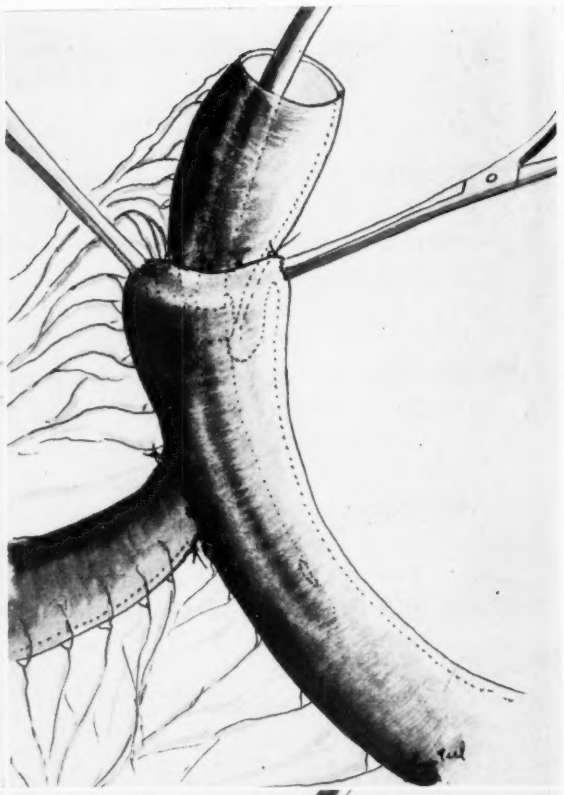


Fig. 2.



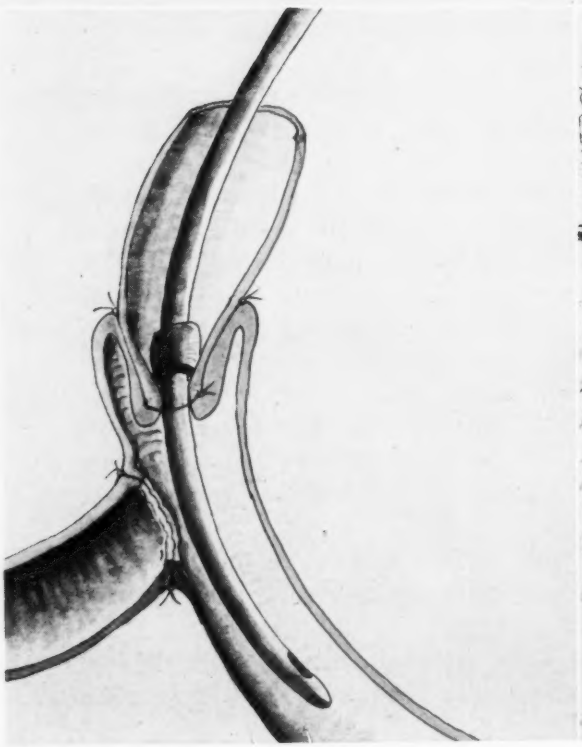


Fig. 3.

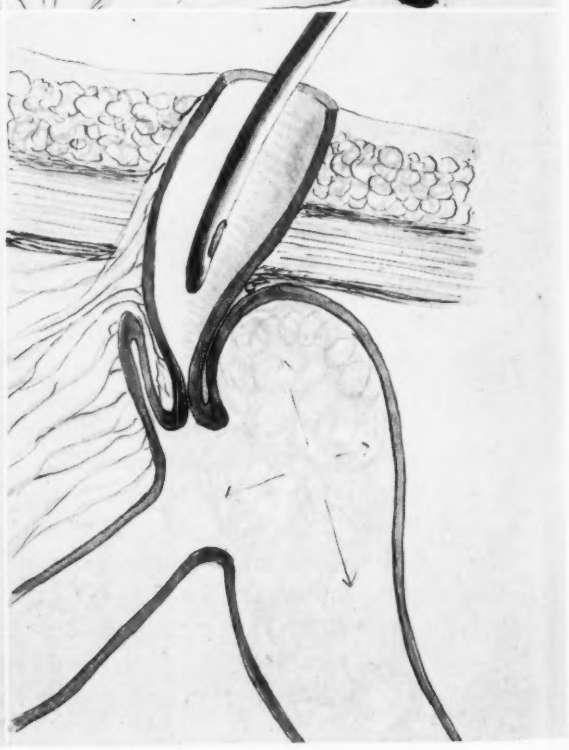


Fig. 4.

(For legends see opposite page.)

as a valve, permitting the introduction of the feeding tube, but preventing the escape of the intestinal contents after the tube is removed.

While this operation is a palliative measure in upper alimentary obstructions, its principle can be employed in such surgical procedures as cholecystojejunostomy or choledochojejunostomy to reduce the incident of ascending infection from the bowel into the biliary system.

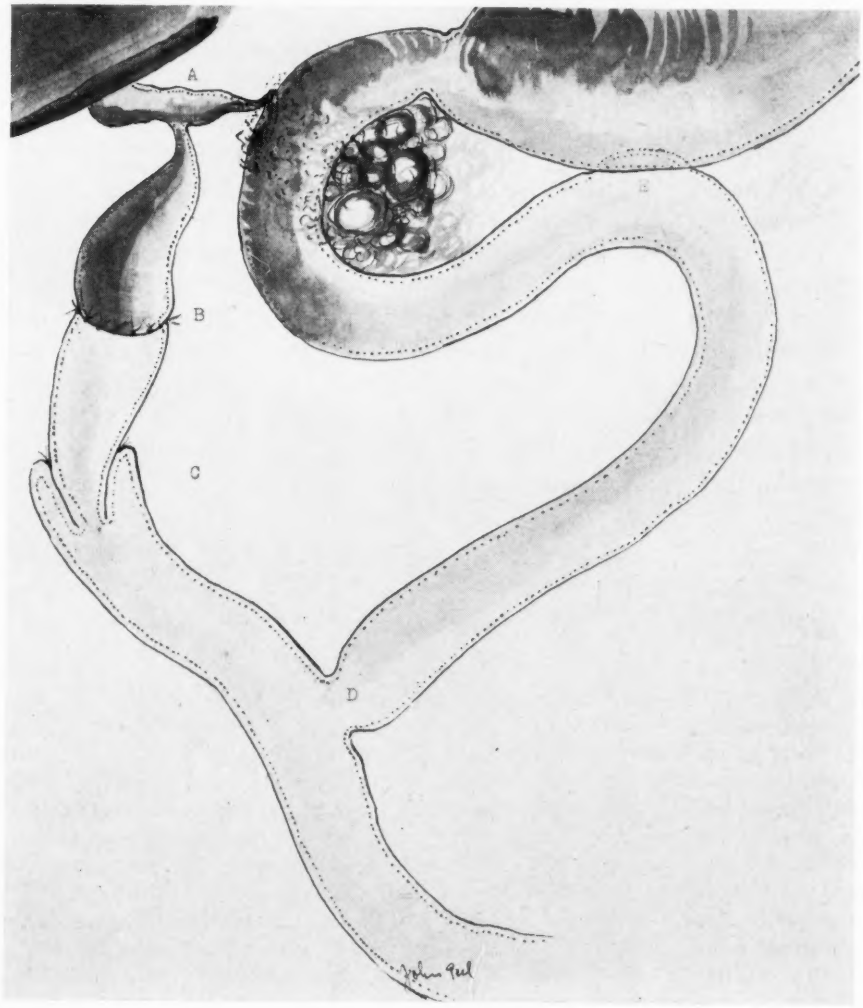


Fig. 5.—*A*, Dilated common bile duct; retroduodenal part obliterated. *B*, Cholecystojejunostomy. *C*, Intussuscepted conical valve in the jejunum permitting free flow of bile, but preventing intestinal contents from entering gall bladder. *D*, Terminolateral jejunostomy. *E*, Gastrojejunostomy.

Fig. 1.—Maydl type jejunostomy completed. Catheter in jejunal stump. Purse string is tied and it "engages" catheter within stump. Next step is to invert bowel with the help of this catheter, while the wall is steadied with the Allis forceps.

Fig. 2.—Jejunal stump inverted, establishing an intussuscepted conical valve. Interrupted silk sutures are placed along the external contact fold of the intussusception.

Fig. 3.—Sagittal section of the bowel at the site of the "valve." The approximately 1 inch broad serosal contact between the "entering" and "receiving" part of the gut readily forms adhesions, which, in addition to the purse string at the tip and the interrupted sutures at the base of the valve insures the latter against eversion.

Fig. 4.—Catheter is removed after instillation of feeding. Note how the increased intrajejunal pressure tends to flatten the valve against the bowel wall. The tip of the valve collapsed as soon as the catheter was withdrawn, thus providing an effective barrier against regurgitation.

Case Reports

BILATERAL MAMMARY CARCINOMA IN THE MALE COINCIDENT WITH PROLONGED STILBESTROL THERAPY

RICHARD R. HOWARD, M.D., AND WENDELL A. GROSJEAN, M.D., WINFIELD, KAN.

THE influence of estrogens in the development of mammary carcinoma in mice was shown by Lacassagne,[7] in 1932, and many others since have noted this carcinogenic effect in not only mice but many other experimental animals.[4, 6, 8] But whether estrogenic therapy has any carcinogenic effect in the development of mammary cancer in the human being has not been established. Foote and Stewart[5] have shown that breast hyperplasia induced by estrogens differs from that seen in neoplasia; however, three cases of carcinoma of the breast in the female have been reported in which the respective authors felt that estrogen therapy was possibly an etiologic factor.[2, 3, 9] In January, 1948, Abramson and Warshawsky[1] reported a case of bilateral carcinoma of the male breast which developed during the course of Stilbestrol therapy for carcinoma of the prostate.

The following is a case report of a male who also developed bilateral carcinoma of the breast coincident with prolonged stilbestrol therapy for carcinoma of the prostate.

CASE REPORT

G. W. P., a 71-year-old white male, was admitted to the hospital on July 27, 1943, with the following complaints: Frequency of urination; nocturia with increasing severity; pain in the hips; loss of weight for one year; and exhaustion. Previous to these complaints his health had been good. Family history was negative. On the first hospital admission, the essential physical findings were an enlarged, hard, nodular prostate, emaciation, and a marked anemia. Red blood cells numbered 2,760,000; hemoglobin, 7.5 Gm.; white blood cells, 10,550; differential, normal. Blood chemistry: Urea nitrogen, 28.1; creatinine, 1.65; sugar, 81 mg. per cent. Gastrointestinal and gall bladder x-ray views were normal. X-ray pictures of the spine and pelvis showed widespread metastatic lesions with osteoplastic changes dominating. A diagnosis of carcinoma of the prostate with bone metastasis was made and the patient was placed on 0.1 mg. diethylstilbestrol daily. One month later, there was marked relief of symptoms, gain of weight, and the prostate was reported to be smaller. He was advised to continue 0.1 mg. of stilbestrol daily indefinitely and he was given a course of x-ray therapy to the prostate. In January, 1944, the patient returned to work and throughout the war years was able to maintain a job in a war plant without difficulty.

On April 5, 1946, the patient returned complaining of generalized bone pain over the entire body and at that time bilateral enlargement of the breasts was noted. He had continued to take stilbestrol as advised. Partial relief of pain was obtained by codeine and Aspirin but was unsatisfactory and on Dec. 13, 1946, he was readmitted to the hospital with the complaints of weakness, lassitude, poor appetite, chest pain, pain in shoulders and hips, pain in the legs, and soreness in the breasts. Examination showed an emaciated man, chronically ill with hypertrophied mammary glands containing small, hard, nontender nodules.

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Nipples were normal but there was pigmentation of the areola. There were no masses in the abdomen. The pubic hair was scanty and the prostate was smaller than originally and was described as soft and boggy except for one hard nodule in the lower right lobe. Roentgenograms of the skeleton at this time showed all bones of the pelvis, spine, thoracic cage, and femur involved in an osteolytic and osteoplastic process (Fig. 1). On the day of admission, the patient's dosage of stilbestrol was increased to 5 mg. daily with rapid alleviation of symptoms. The dosage of the drug was steadily increased until Dec. 5, 1946, when the patient was taking 120 mg. of stilbestrol daily. An effort was being made to inhibit completely all endogenous sources of androgen. On his dismissal from the hospital, the dosage of stilbestrol was decreased to 80 mg. a day, which he continued to take until his death on Jan. 4, 1948. After the dosage of the drug was increased, it was noted that the breast decreased in size, lost the tenderness, and became harder. From Nov. 13, 1946, until Dec. 19, 1947, he had no symptoms of any consequence except intermittent weakness which was relieved by transfusions; a total of 9,550 c.c. of citrated blood being administered during this time. He was admitted to the hospital for the last time on Dec. 19, 1947, because of the development of chills and fever and pain in the right lumbar region which became progressively worse. Before death on Jan. 4, 1948, he developed gross hematuria and pain simulating renal colic.

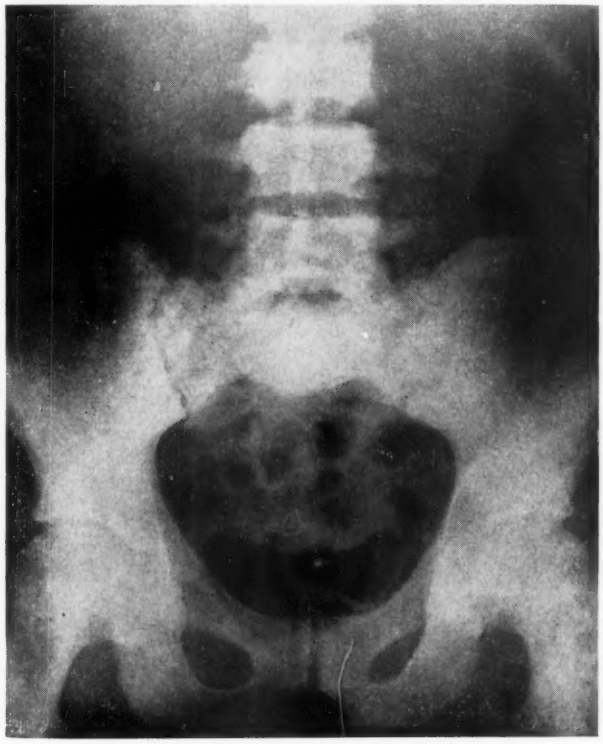

Fig. 1—X-ray view of pelvis and spine taken December, 1946, showing extensive metastatic lesions.

The total dose of diethylstilbestrol that this patient received from July 27, 1943, to Nov. 13, 1946, was 120 mg. From Nov. 13, 1946, to Jan. 4, 1948, he received a total of 40,160 mg. of diethylstilbestrol.

Autopsy Report.—The body was that of an emaciated man. Both breasts were enlarged, hard, and nodular, being elevated approximately 2 cm. and measuring 8 cm. in diameter. The nipples were normal for a man, but the areola was moderately pigmented. The breast tissue mass was only slightly adherent to the pectoralis fascia; the nipples were adherent to the

underlying mass. On cross section, the breast tissue consisted of dense, whitish, fibrous-like tissue with small yellowish patches throughout. The ribs showed gross evidence of multiple metastatic lesions. There was no evidence of metastasis to the lungs or pleura. The heart showed nothing unusual. There was a minimal amount of atherosclerosis of the thoracic and coronary vessels. The abdominal aorta showed extensive atherosclerosis. The gastrointestinal tract was normal. The messentery contained multiple small nodules. A large lesion was present anterior to the right kidney which was adherent to the hepatic flexure of the colon. The liver was enlarged but only four metastatic lesions were found, which measured from 4 to 5 mm. in diameter. The pancreas, biliary tract, and spleen were uninvolved. Both adrenal glands were approximately twice the normal size and were extensively involved with tumor tissue which invaded the perirenal fat. The left kidney was grossly normal. The right kidney, however, showed an extensive hemorrhagic pyelohydronephrosis secondary to a small encircling metastatic growth in the upper portion of the right ureter which almost occluded it. There was no metastatic lesion of the kidney itself. The prostate was small and made up of hard, fibrous-like tissue.

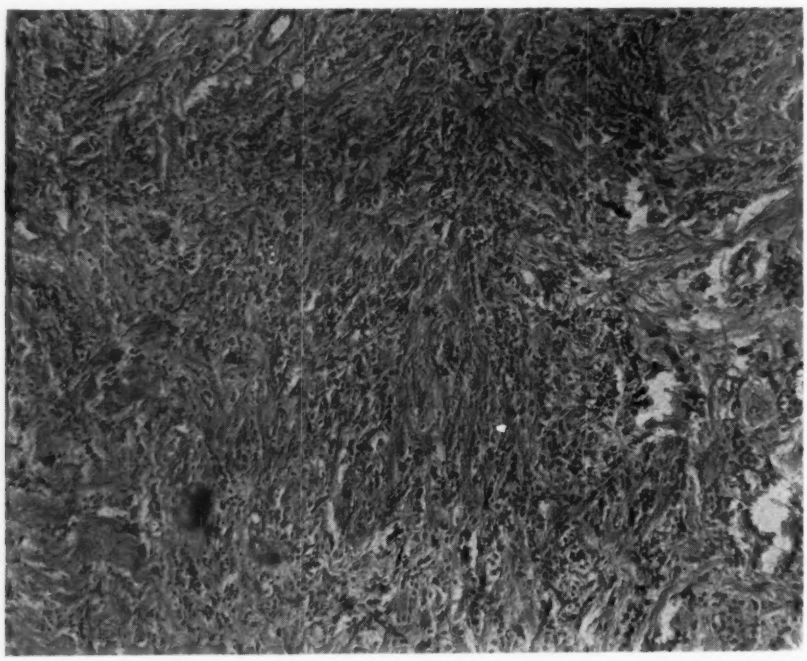

Fig. 2—Autopsy tissue section from left breast showing scirrhous type carcinoma, January, 1948.

Microscopic Examination.—Sections of the breast showed infiltrated cords of atypical cells in a rather dense stroma. Most of the cells contained a moderate amount of pink, granular, or clear cytoplasm with polyhedral outlines. The nuclei were rounded or irregular in shape and appeared vesicular. Mytosis was rare. The ducts were lined by irregular-appearing cuboidal or columnar epithelium and did not appear to participate in the process. The carcinoma was scirrhous in character (Fig. 2). Sections of the ribs showed an anaplastic type of metastatic carcinoma. Sections of the lungs showed a small mass of cells which were thought to be degenerated tumor cells. They were located mostly around the blood vessels and bronchi. There appeared to be no active growth in these cells. Sections of the liver showed small fossae of tumor cells, anaplastic in character. The adrenal glands presented the same type of growth. Sections of the prostate showed marked fibrosis, the only evidence of carcinoma being in the tissue directly surrounding it. There was some squamous metaplasia present. Sections of the testes showed complete atrophy.

SUMMARY

A case is reported of a man on whom a clinical diagnosis of carcinoma of the prostate with bone metastasis was made on July 27, 1943. From this date until his death on Jan. 4, 1948, he received a total of 40,280 mg. of diethylstilbestrol. At the time of death, bilateral scirrhous carcinoma of the breast was present.

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LEIOMYOMA OF THE ESOPHAGUS

Report of a Case

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BENIGN tumors of the esophagus are rare. In a review of 7,459 post-mortem examinations performed at the Mayo Clinic, only 44 benign tumors of the esophagus were found. Moersch and Harrington[1] reported 15 benign esophageal tumors in a study of 11,000 patients who complained of dysphagia. Of these 15 tumors, only 2 were leiomyomas. Rose[2] reviewed 49 cases of myomas of the esophagus reported up to 1936. He stated that these tumors were found predominantly in males (3:1) and were multiple in 11 cases. They occurred in the upper third of the esophagus in 8 cases, the middle third in 18 cases, and the lower third in 28 cases. The larger tumors became pedunculated and tended to encircle the esophagus.

There has been a paucity of reports concerning the surgical removal of myomas of the esophagus. Schafer and Kittle[3] found only 4 patients who had been operated upon reported in the literature, of whom 2 survived surgery. They reported a third successful operation which involved removal of the tumor with subsequent suture of the vertical opening made in the mucosa and repair of a coexisting diaphragmatic hernia. Since these lesions are derived from the muscle layer of the esophagus and rarely involve the mucosa, excision of the mucous membrane during enucleation should prove to be unnecessary and certainly more hazardous.

The following case report represents an additional successful excision of a leiomyoma.

CASE REPORT

A man, aged 31 years, entered the hospital Feb. 24, 1947, complaining of a protrusion in the left inguinal area. He had no gastrointestinal complaints. The routine chest roentgenogram revealed an ovoid mass measuring about 3 by 5 cm. just to the right of the midline and superimposed on the right supracardiac shadow. Outline of the esophagus with barium showed the previously described mass to lie just below the coryna, causing an indentation of the anterior wall of the esophagus (Fig. 1). The appearance and localization of this mass were most suggestive of a bronchiogenic cyst.

The patient underwent a left inguinal herniorrhaphy on Feb. 27, 1947, followed by an uneventful postoperative course. On March 14, under endotracheal anesthesia, the seventh rib was removed on the right side and the pleura opened. The right lung was retracted mesially and the posterior mediastinum exposed. A firm, somewhat lobulated mass was seen through the mediastinal pleura. On opening this pleura, the mass was found to be firm and attached to the anterior and lateral walls of the esophagus about 1 inch below the azygos vein. The mass encircled three-quarters of the esophagus like a collar and protruded through a defect in the longitudinal fibers. The tumor was removed by sharp and blunt dissection. The mucosa bulged out at the end of the procedure but was left intact. The longitudinal muscle was approximated with interrupted silk. The incision was closed in layers with silk.

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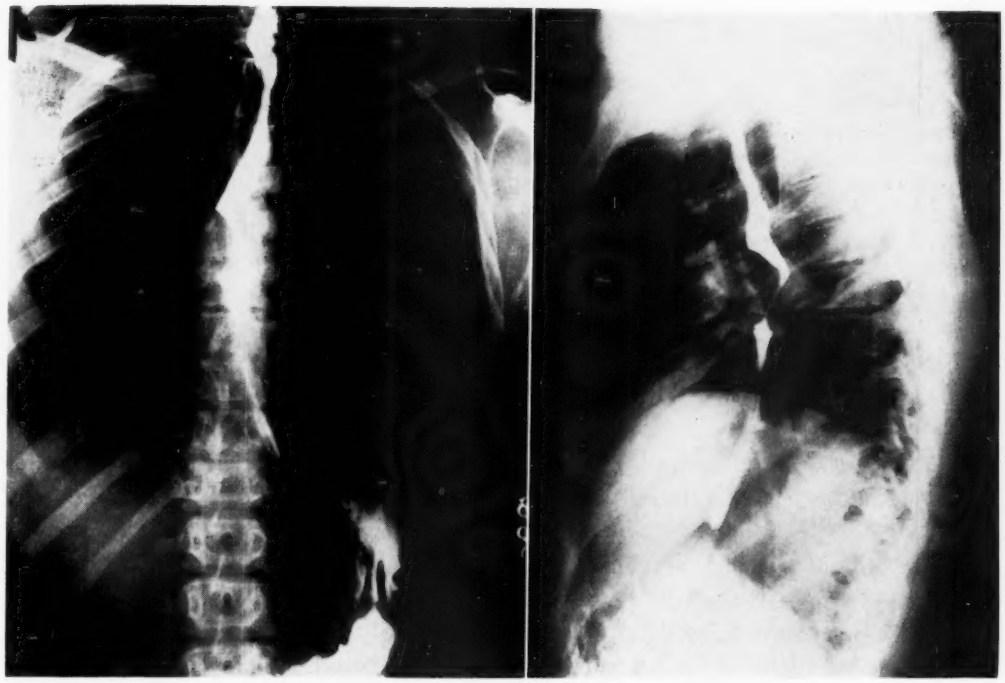

Fig. 1.—Anteroposterior and lateral films reveal the sharp indentation made in the mid-esophagus by the leiomyoma.

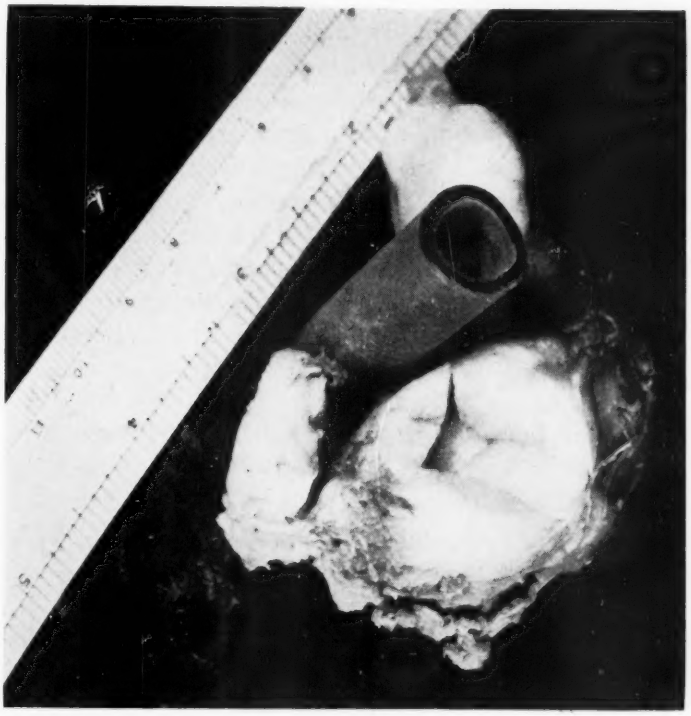

Fig. 2.—The cut surface reveals the "fibroid" appearance of the lesion. The lateral projections that indent the esophagus can be seen.

The patient withstood the procedure well and made an uneventful recovery. He was given fluids on the first postoperative day and food on the fifth day. A barium swallow postoperatively revealed absence of the tumor previously described.

Pathologic Examination.—Gross: Specimen (Fig. 2) consisted of a U-shaped mass of well encapsulated, firm, gray-white tissue, weighing 42.5 grams. The central isthmus measured 5.2 cm. long by 2.0 by 2.8 cm. in diameter. The two arms of the U projected backward, having partially enclosed the esophagus. The one on the left side measured 3.5 by 2.6 by 1.6 cm. The one on the right was slightly smaller, measuring 3 by 2.5 by 1.1 cm., and sent a small knob posteriorly around the esophageal enclosure. Cut section of the tumor revealed the typical whirled, white, moiré pattern of leiomyomas. There were no gross areas of hemorrhage or necrosis.

Microscopic: The tumor consisted entirely of whirling, interlacing bundles of smooth muscle cells in which small areas of fibrosis and calcification occurred. There was no evidence of malignancy.

Diagnosis.—Leiomyoma, esophagus.

Comment.—Since symptoms are absent in most cases of benign tumors of the esophagus, the diagnosis is usually made by roentgenography. Schatzki and Hawes[4] emphasized the characteristics of extramucosal, intramural tumors of the esophagus. They stated that the profile view showed "an abrupt, sharp angle where the edge of the tumor met the uninvolved wall of the esophagus." Although the esophagus often appeared markedly narrowed in the involved area, no obstruction to the passage of barium was noted. This phenomenon was due to the fact that the wall opposite the lesion had retained its normal elasticity and stretched out to accommodate the barium that was swallowed. According to these authors the differentiation between intramural lesions and attached extrinsic lesions may be more difficult. The former, however, usually produce a greater intraluminal protrusion. The diagnosis of an intramural tumor of the esophagus should have been entertained in this case because of the sharp angulation of the esophagus, with a normal mucosal pattern and absence of symptoms. The compression of both lateral walls of the esophagus by the tumor should have lent support to the diagnosis of an encircling myoma of the esophagus.

Since these tumors are invariably extramucosal, an attempt should be made to excise them without entering the esophageal lumen. If this maneuver is successful, the morbidity and mortality should prove negligible.

SUMMARY

1. Successful removal of a leiomyoma of the mid-esophagus has been described.

2. Roentgenographic features of this disease have been emphasized.

3. An attempt should be made to remove these tumors by an extramucosal dissection.

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Recent Advances in Surgery

Conducted by Alfred Blalock, M.D.

INGUINAL HERNIA IN INFANCY AND EARLY CHILDHOOD

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THERE is great variation of opinion regarding the methods and time for treatment of inguinal hernia in infants and young children. There are some physicians who recommend no treatment, others a truss of their particular fancy, and still others who advise operation for uncomplicated inguinal hernia; although frequently neither the efficacy nor the risk of the course recommended is fully appreciated.

To avoid the risk of operation in this early age group, a risk which has been greatly exaggerated, many physicians recommend the use of a truss, disregarding the hazards of this form of treatment and, equally important, completely overlooking the tremendous emotional strain placed upon the parent by fear of incarceration and awareness of a genital abnormality in their issue, and the attendant irreversible effect of this abnormal environment on the emotional development of the infant and young child.

It is not remarkable that experienced physicians, aware of these inconsistencies and disgusted with massive ulceration, filth, attendant testicular atrophy, and failure of the truss to retain the hernia, have concluded that the child is better off with no treatment at all.

It is remarkable that, ignoring all the risks of the hernia, this group of physicians defers treatment of the hernia until the child is 5 or 6 years of age, supposedly because with larger structures herniorrhaphy can be more safely or successfully accomplished, rather than recommending the highly safe and successful immediate herniorrhaphy.

It is hoped that the following analysis of the records of 111 patients from birth through 6 years of age, treated in the Vanderbilt University Hospital from 1925 through 1947, will make possible an evaluation of the methods of treatment and the age of the patient when the treatment should be carried out in infants and young children with inguinal hernia.

TREATMENT BY OPERATION

The preadmission treatment, with few exceptions, has not been determined by the surgical staff of Vanderbilt University Hospital.

Of 111 patients in this age group admitted with inguinal hernia, 101 have been operated upon for 119 inguinal hernias. One hundred eight of these herniorrhaphies were performed in the Vanderbilt University Hospital; eleven were done elsewhere. Seven of the eleven done elsewhere were in patients past 6 years of age when operated upon. Four of these past 6 years of age when operated upon had very late contralateral operations, and are not included in this study.

With few exceptions the age at operation is the approximate age at which the patient first came under our care.

TABLE I. TREATED BY YARN TRUSS

NUMBER	INFANTILE	SIMPLE	BILATERAL	HYDROCELE	AGE AT ONSET	DURATION OF TRUSS	RETAINED	INCREASE IN SIZE	REPEATED INCARCERATION	IRREDUCIBLE INCARCERATION	ATROPHY OF TESTICLE	DURATION OF APPARENT CURE	SUBSEQUENT OPERATION
118353	L				54 mo.	5 mo.	No	Yes	No	No	No		60 mo.
151669	R				Birth	10 wk.	No	Yes	No	No	No		10 wk.
151669	L			C.	Birth	8 mo.	No	Yes	No	No	No		8 mo.
131566		R			Birth	8 mo.	No	No	Yes	No	No		24 mo.
127851		R			6 mo.	18 mo.	No	No	No	Yes	No		24 mo.
144688	R				Birth	72 mo.	No	Yes	Yes	No	No		72 mo.
4553		R			12 mo.	12 mo.	No	No	No	No	No		48 mo.
10772	L	R			24 mo.	48 mo.	Yes	Yes	No	No	No		72 mo.
22678	R				Birth	48 mo.	No	Yes	No	No	No		48 mo.
30376		L			24 mo.	12 mo.	No	Yes	No	No	No		72 mo.
45629		X	X		3 mo.	45 mo.	No	Yes	Yes	No	No		60 mo.
45780		L			59 mo.	1 mo.	No	Yes	No	No	F.		60 mo.
24427	R				Birth	14 yr.	No	Yes	No	No	Yes		16 yr.
103551	L				Birth	60 mo.	No	No	Yes	No	No		60 mo.
54786		R			12 mo.	48 mo.	No	No	Yes	No	No		60 mo.
32229	R				Birth	15 mo.	No	No	No	No	No	17 yr.	
31925	L				Birth	2 mo.	Yes	No	No	No	F.	15 yr.	
142711		L			3 mo.	18 mo.	Yes	No	No	No	F.	2 yr.	
163467	R				9 mo.	15 mo.	No	No	No	No	No		24 mo.
155184	L				Birth	9 mo.	No	No	Yes	No	F.		9 mo.
140414	R			C.	28 mo.	8 mo.	No	Yes	Yes	No	No		36 mo.
52865	R	L			2 mo.	18 mo.	No	Yes	Yes	No	No		20 mo.
53039		R			13 mo.	1 mo.	No	Yes	Yes	Yes	No		17 mo.
115151	R			N.C.	3 mo.	16 mo.	No	No	Yes	No	No		19 mo.
102439	R			N.C.	24 mo.	12 mo.	No	Yes	No	No	No		36 mo.
95147		L			Birth	18 mo.	No	No	No	No	No		36 mo.
85375		R			48 mo.	24 mo.	No	No	No	No	No		72 mo.
54216		R			7 wk.	3 wk.	No	No	No	Yes	No		10 wk.
92342		R			36 mo.	36 mo.	No	Yes	Yes*	No	No		72 mo.
87992		R			Birth	13 mo.	No	No	Yes	Yes	No		24 mo.
81375		R			22 mo.	2 mo.	No	No	Yes*	Yes	No		30 mo.
4777	R				44 mo.	7 yr.	Yes	No	No	No	No	20 yr.	
21268	L				Birth	48 mo.	No	Yes	No	No	No		48 mo.
54101		R			10 mo.	6 mo.	No	Yes	No	No	No		60 mo.
395		X	X		12 mo.	12 yr.	No	Yes	Yes	No	No		20 yr.
131666		R			15 mo.	1 mo.	No	No	No	Yes	No		16 mo.
36	18	22	4	4			32	18	14	6	1	4	32

*Previously reduced under general anesthetic elsewhere.

PREOPERATIVE CARE

All patients were admitted at least twenty-four hours before operation. They received careful physical examination and, during the past five years, they received preoperative penicillin or sulfonamide of average acceptable therapeutic dosage for their weight.

The usual preoperative precautions regarding hydration were carried out. Parenteral fluid was required only in very hot weather.

During the past five years none received preoperative sedatives.

With the exceptions shown in Table III, an interval of one to three months is recommended between herniorrhaphies for simultaneously present bilateral hernias.

ANESTHETIC AGENT

Only one operation was performed under local Novocain anesthesia. Drop ether was used as the anesthetic agent for all other patients operated upon.

The one death which occurred was attributed to ventricular fibrillation. Ether saturation in the ventricular blood, obtained immediately after respiration ceased, was revealed in a blood sample of 3 c.c. Ether found was 3.7 mg., or

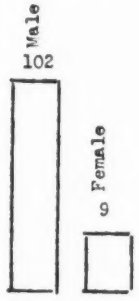


Fig. 1.—Sex distribution.

23 mg. per 100 c.c., determined by the iodine pentoxide method. The arterial pulsation and cardiac beat suddenly became imperceptible, while breathing continued without cyanosis, just as the repair of the abdominal wall was started twenty minutes after the onset of the operation.

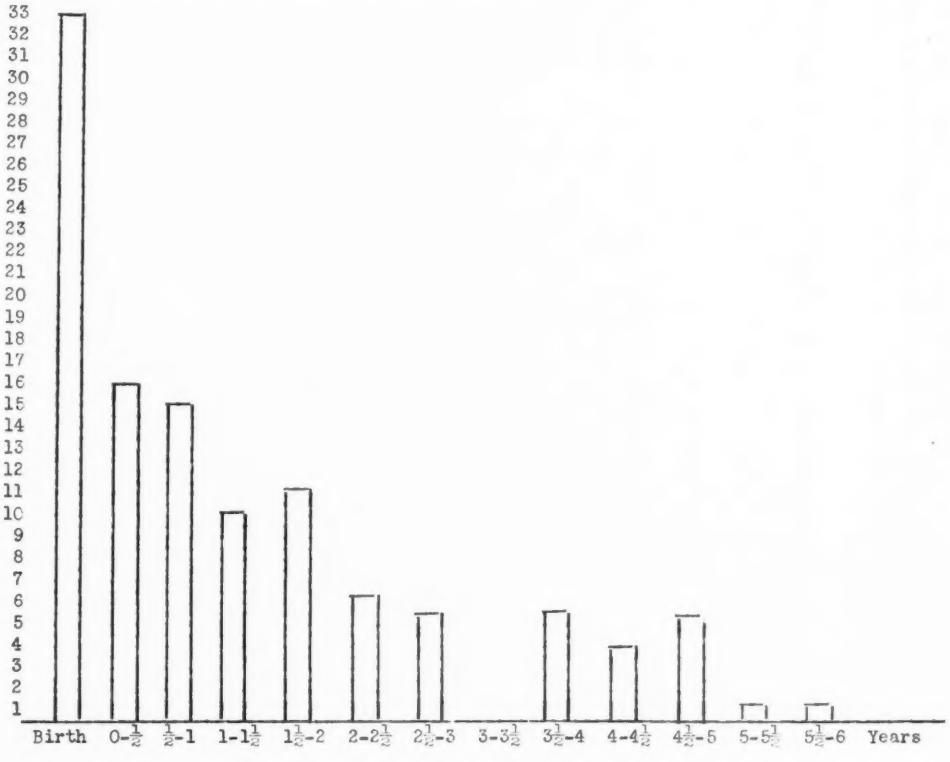
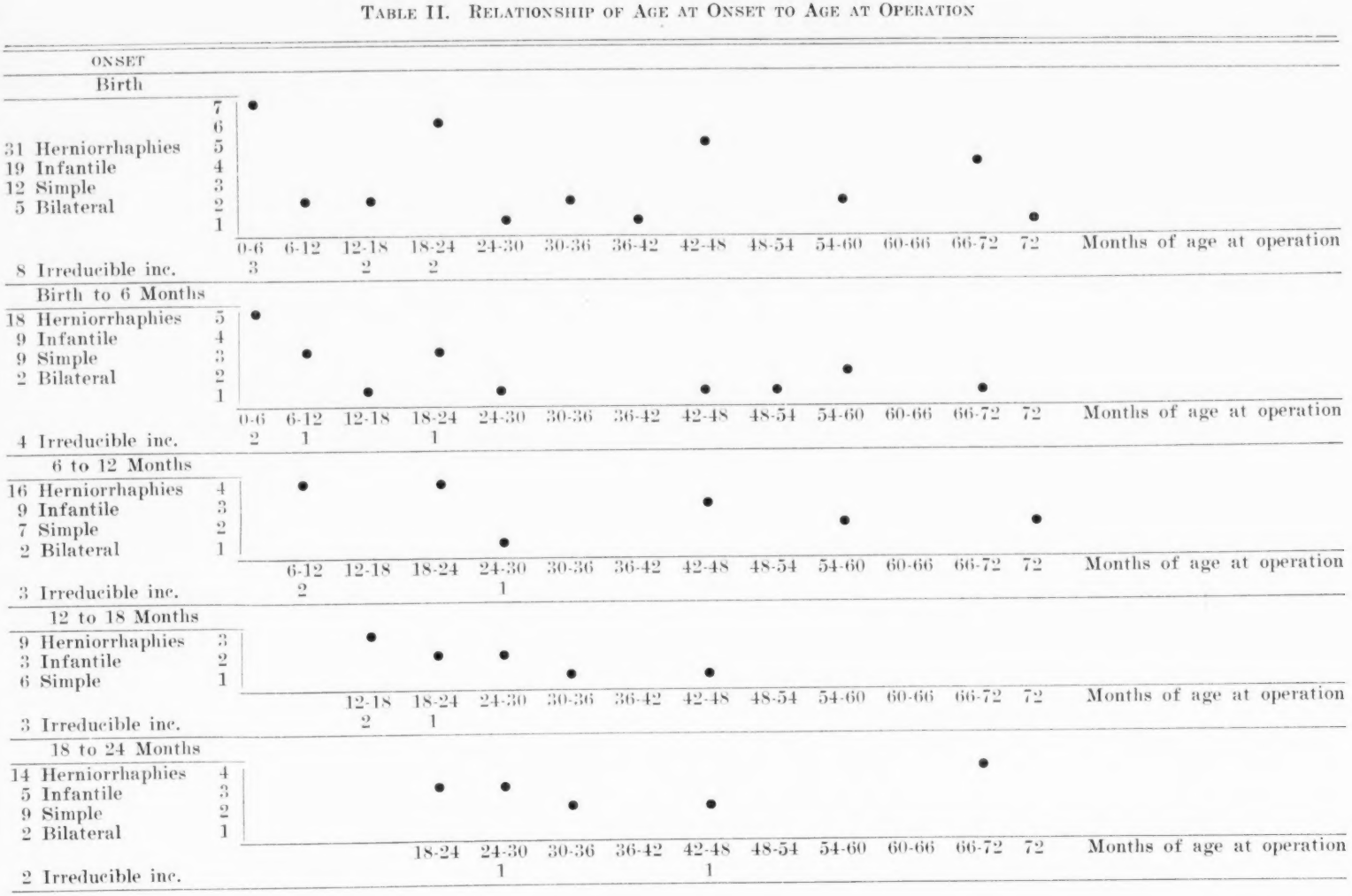


Fig. 2.—Age of patient when hernia was first discovered (111 patients).

TABLE II. RELATIONSHIP OF AGE AT ONSET TO AGE AT OPERATION



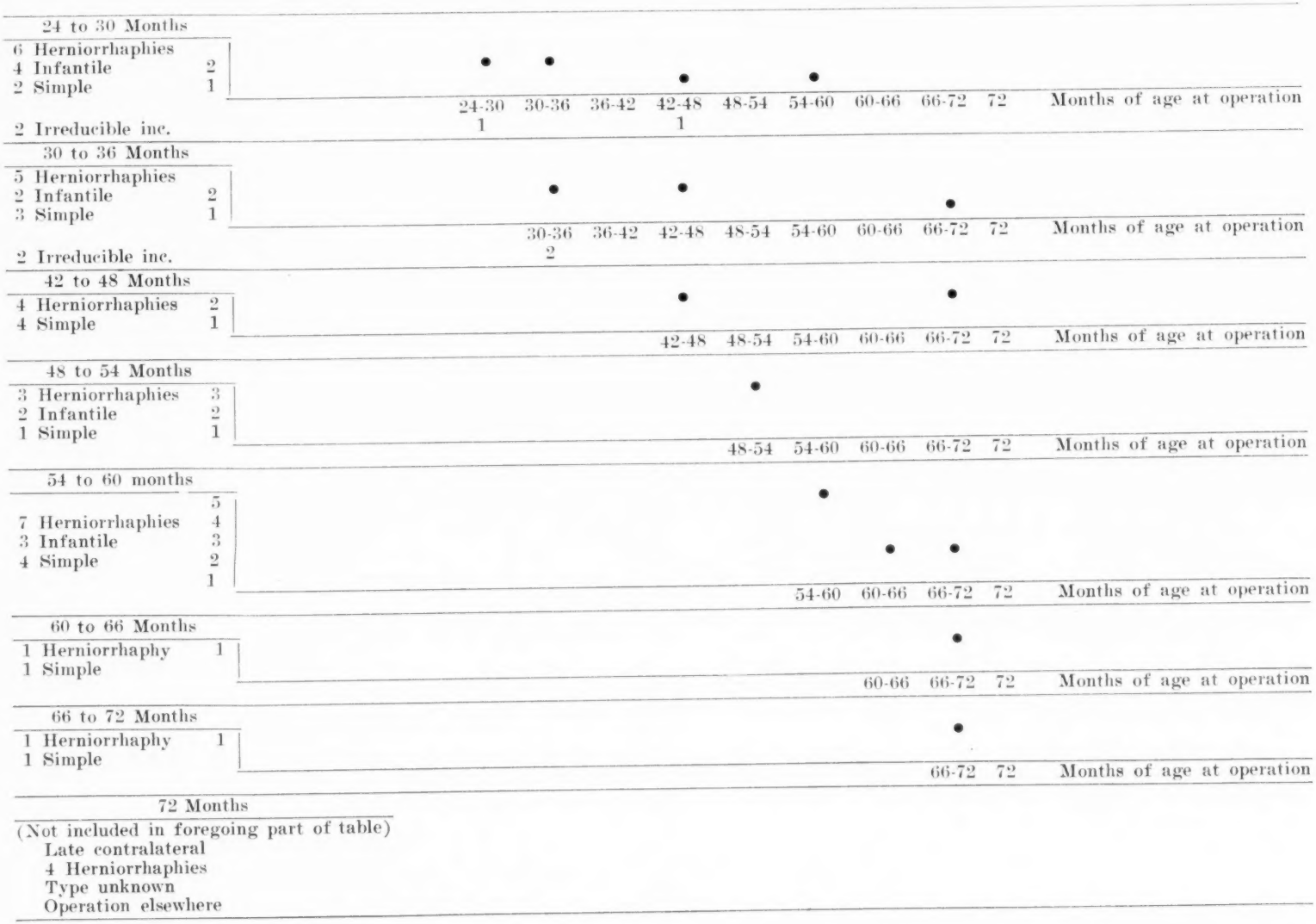

24 to 30 Months
6 Herniorrhaphies
4 Infantile 2
2 Simple 1
2 Irreducible inc.
24-30 30-36 36-42 42-48 48-54 54-60 60-66 66-72 72 Months of age at operation
1 1
30 to 36 Months
5 Herniorrhaphies
2 Infantile 2
3 Simple 1
2 Irreducible inc.
30-36 36-42 42-48 48-54 54-60 60-66 66-72 72 Months of age at operation
2
42 to 48 Months
4 Herniorrhaphies 2
4 Simple 1
42-48 48-54 54-60 60-66 66-72 72 Months of age at operation
48 to 54 Months
3 Herniorrhaphies 3
2 Infantile 2
1 Simple 1
48-54 54-60 60-66 66-72 72 Months of age at operation
54 to 60 months
5
7 Herniorrhaphies 4
3 Infantile 3
4 Simple 2
1
54-60 60-66 66-72 72 Months of age at operation
60 to 66 Months
1 Herniorrhaphy 1
1 Simple
60-66 66-72 72 Months of age at operation
66 to 72 Months
1 Herniorrhaphy 1
1 Simple
66-72 72 Months of age at operation
72 Months
(Not included in foregoing part of table)
Late contralateral
4 Herniorrhaphies
Type unknown
Operation elsewhere

TABLE III

NO.	TYPE	AGE AT ONSET	DURATION	AGE AT OPER.	TESTES	TRUSS	IRREDUCIBLE INCARCERATION	OPERATION R.C.	OPERATION M.C.	OPERATION B.O.	OPERATION P.T.	P.O. COURSE	FOLLOW-UP
4553	Simple (R)	12 mo.	36 mo.	48 mo.	Down	12 mo.	No	x				Uneventful	20 yr., OK
22678	Infantile (R)	Birth	48 mo.	48 mo.	Down	48 mo.	No	x		x		Uneventful	Not followed
30376	Simple (L)	24 mo.	48 mo.	72 mo.	Down	12 mo.	No	x				Uneventful	11 yr., Army, OK
45780	Simple (L)	59 mo.	1 mo.	60 mo.	F.	1 mo.	No	x				Uneventful	15 yr., OK
115151	Infantile (R) N.C.Hyd. C. & T.V.	3 mo.	16 mo.	19 mo.	Down	16 mo.	No	x				Uneventful	6 yr., OK
102439*	Infantile (R) N.C.Hyd. C. & T.V.	24 mo.	12 mo.	36 mo.	Down	12 mo.	No	x		x		Uneventful	5 yr., OK
95147	Simple (R)	Birth	36 mo.	36 mo.	Down	18 mo.	No	x				Uneventful	8 yr., OK
99799	Simple (R)	64 mo.	8 mo.	72 mo.	Down	No	No	x				Uneventful	3 yr., OK
146723	Simple (R)	Birth	24 mo.	24 mo.	Down	No	No	x				Dead, ventricular fibrillation	
146723	Simple (L)	21 mo.	3 mo.										
99908	Simple (L)	Birth	72 mo.	72 mo.	Down	No	No	x				Uneventful	3 yr., OK
99908	Simple (R)	Birth	9 yr.	9 yr.	Down	No	No	x				Uneventful	3 mo., OK
159803	Infantile (R) N.C.Hyd. C. & T.V.	59 mo.	1 mo.	60 mo.	Down	No	No		x	x		Uneventful	6 mo., OK
158770	Simple (R)	2 mo.	1 wk.	2 mo.	Down	No	No	x				Uneventful	6 mo., OK
157826	Infantile (R)	24 mo.	1 mo.	25 mo.	F.	No	No	x				Uneventful	8 mo., OK

153211	Infantile (R)	Birth	60 mo.	60 mo.	Und. (R)	No	No	x	x	x	Uneventful	1 yr., OK Testicle OK
152668	Simple (L)	21 mo.	9 mo.	30 mo.	Down	No	No	x			Uneventful	1 yr., OK
152052	Infantile (L) C.Hyd. C. & T.V.	1 mo.	47 mo.	48 mo.	Down	No	No	x	x		Uneventful	1 yr., OK
150813	Infantile (R)	Birth	24 mo.	24 mo.	Down	No	No	x			Uneventful	1½ yr., OK
150290	Simple (L)	48 mo.	24 mo.	72 mo.	Down	No	No		x		Uneventful	1½ yr., OK
147748	Simple (R)	12 mo.	2 hr.	12 mo.	Down	No	2 hr.†	x			Uneventful	2 yr., OK
146397	Infantile (L)	3 mo.	13 mo.	16 mo.	F.	No	No	x			Uneventful	2 yr., OK
145545	Infantile (L)	12 mo.	8 mo.	20 mo.	Down	No	No	x			Uneventful	2 yr., OK
144841	Infantile (R) N.C.Hyd. C. & T.V.	54 mo.	6 mo.	60 mo.	Down	No	No	x	x		Uneventful	2 yr., OK
54101*	Simple (R)	10 mo.	50 mo.	60 mo.	Down	6 mo.	No	x			Uneventful	9 yr., OK
53699	Infantile (R)	Birth	3½ mo.	3½ mo.	F.	No	2 days	x Salpingo-cophorectomy			Uneventful	14 yr., OK
116339	Simple (R)	24 mo.	24 mo.	48 mo.	Down	No	2 hr.	x			Uneventful	Not followed
111534	Simple (L)	15 mo.	6 mo.	21 mo.	Down	No	6 hr.† Attempt at reduction under gen. anesthetic	x			Uneventful	Not followed
83479	Simple (R)	18 mo.	12 mo.	30 mo.	Down	No	No	x			Uneventful	10 yr., OK
79711	Simple (R)	Birth	21 mo.	21 mo.	Down	No	5 hr.	x			Uneventful	9 yr., OK
139057	Infantile (Bil.)	12 mo.	12 mo.	24 mo. not V.U.H.	Down	No	No	x Bil.			Uneventful	1 yr., OK

(Continued on following pages)

TABLE III—CONT'D

NO.	TYPE	AGE AT ONSET	DURATION	AGE AT OPER.	TESTES	TRUSS	IRREDUCIBLE INCARCERATION	OPERATION E.C.	OPERATION M.C.	OPERATION B.O.	OPERATION P.T.	P. O. COURSE	FOLLOW-UP
395	Simple (Bil.)	12 mo.	19 yr.	20 yr.	Down	12 yr. irreg. ular	No	Operation age 20 yr. Bil. elsewhere x				Uneventful	2 yr., OK
88436	Simple (R)	Birth	1½ mo.		Down	No	No	None advised					Died—age 3 mo., congenital heart disease
52662	Simple (Bil.)	Birth	5 wk.		Down	No	No	None advised					Died—age 7 mo., elsewhere (?) Cause
28686	Simple (R)	Birth	2 mo.		Down	No	No	None advised					Not followed
26995	Infantile (R)	Birth	10 mo.		Down	No	No	None advised					Not followed
24089	Infantile (L)	Birth	2 mo.		F.	No	No	Treatment—operation deferred					Not followed
4777	Infantile (R)	44 mo.	4 mo.		Down	7 yr.	No	Advised-refused					20 yr., apparent cure, construction work
125246	Infantile (R) C.Hyd. C. & T.V.	15 mo.	3 mo.		Down	No	No	Deferred—did not return for oper.					1 yr., still had hernia
144475	Infantile (R) C.Hyd. C. & T.V.	18 mo.	18 mo.	36 mo.	Down	No	No; Aspirated by LMD before admission	x				Uneventful	2 yr., OK
144359	Infantile (R)	4 mo.	2 wk.	4 mo.	F.	No	No	x				Uneventful	2 yr., OK
142065	Infantile (R)	5 mo.	24 hr.	5 mo.	Down	No	24 hr.‡	x				Uneventful	2 yr., OK
138649	Infantile (L)	30 mo.	2 wk.	30 mo.	Down	No	No	x				Uneventful	1 yr., OK
137732	Infantile (R)	7 mo.	1 wk.	7 mo.	Down	No	24 hr.†	x		x		Uneventful	2½ yr., OK
136464	Infantile (R)	Birth	11 wk.	11 wk.	Und.	No	15 hr.†	x			x	Uneventful	3½ yr., OK
136464	Infantile (L)	Birth	22 mo.	22 mo.	Und.	No	No	x			x	Uneventful	2½ yr., OK
131666	Simple (R)	15 mo.	1 mo.	16 mo.	Down	1 mo.	4 hr.	x				Uneventful	2½ yr., OK

131666	Infantile (L)	22 mo.	3 wk.	22 mo.	Down	No	No	x		Uneventful	2½ yr., OK
130635	Infantile (R) N.C.Hyd. C. & T.V.	30 mo.	30 mo.	60 mo.	Down	No	No		x	Uneventful	1 yr., OK
130112	Infantile (R) N.C.Hyd. C. & T.V.	Birth	37 mo.	37 mo.	Down	No	No	x	x Hernia sac not found at operation	Uneventful	3 mo., OK
125993	Infantile (L) N.C.Hyd. C. & T.V.	18 mo.	29 mo.	47 mo.	Down	No	No; Aspirated by LMD before admission	x	x	Uneventful	1 yr., OK
125219*	Infantile (R)	36 mo.	12 mo.	48 mo.	Down	No	No	x	x	Uneventful	9 mo., OK
124906	Simple (R)	30 mo.	1 wk.	30 mo.	Down	No	3 hr.	x		Uneventful	2 yr., OK
124524	Infantile (L)	11 mo.	2 wk.	11 mo.	Down	No	No	x		Uneventful	5 yr., OK
122762	Infantile (R)	36 mo.	8 hr.	36 mo.	Down	No	8 hr.		x Acute appendicitis, appendectomy by McBurney	Uneventful	5 yr., OK
125869	Simple (R)	9 mo.	39 mo.	48 mo.	Down	No	No	x		Uneventful	6 mo., OK
109455	Infantile (R) N.C.Hyd. C. & T.V.	22 mo.	50 mo.	72 mo.	Down	No	No	x No hernia found at operation		Uneventful	6 mo., OK
81375	Simple (R)	22 mo.	8 mo.	30 mo.	Down	2 mo.	Reduced by LMD lx, chloroform; attempt at reduction 5½ hr., prior to adm. under gen. anesthetic†	x		Uneventful	11 yr., OK
160941	Simple (R)	Birth	72 mo.	72 mo.	Down	No	10 hr.†	x Exploratory laparotomy		Uneventful	7 mo., OK

(Continued on following pages)

TABLE III—CONT'D

NO.	TYPE	AGE AT ONSET	DURATION	AGE AT OPER.	TESTES	TRUSS	IRREDUCIBLE INCARCERATION	OPERATION R.C.	OPERATION M.C.	OPERATION B.O.	OPERATION P.T.	P. O. COURSE	FOLLOW-UP
163467	Infantile (R)	9 mo.	15 mo.	24 mo.	Down	15 mo.	No	x				Uneventful	2 mo., OK
128316	Simple (L)	47 mo.	1 mo.	48 mo.	Down	No	No	x				Uneventful	1 yr., OK
151649	Simple (L)	3 mo.	9 mo.	12 mo.	Down	No	No	x				Uneventful	6 mo., OK
155184	Infantile (L)	Birth	9 mo.	9 mo.	F.	9 mo.	No	x				Uneventful	1 yr., OK
159231	Infantile (L)	1 mo.	53 mo.	54 mo.	Down	No	No	x				Uneventful	7 mo., OK
159231	Infantile (R) C.Hyd. C. & T.V.	56 mo.	4 mo.	60 mo.	Down	No	No	x				Uneventful	1 mo., OK
142711	Simple (L)	3 mo.	18 mo.		F.	18 mo.	No						2 yr., cure
135409	Simple (L)	71 mo.	1 mo.	72 mo.	Down	No	No	x				Uneventful	2 mo., OK
166346	Simple (R)	60 mo.	2 wk.	60 mo.	Down	No	No	x				Uneventful	2 mo., OK
140414	Infantile (R) C.Hyd. C. & T.V.	28 mo.	8 mo.	36 mo.	Down	8 mo.	No	x				Uneventful	2 mo., OK
10964	Infantile (L)	Birth	30 mo.	30 mo.	Down	No	No	x		x		Uneventful	19 yr., OK Marines
13369	Infantile (Bil.)	Birth	3 wk.	3 wk.	Down	No	No	x Bil.		x L.		Uneventful	2 mo., died gon. septicemia
16728	Infantile (R)	12 mo.	18 mo.	30 mo.	Down	No	18 hr.	x Acute appendicitis, appendectomy by herniorrhaphy				Uneventful	10 yr., OK
19815	Simple (Bil.)	Birth	18 mo.	18 mo.	Down	No	2 days‡	x				Uneventful	18 yr., OK Delayed contralateral hernia; repaired age 7 yr., elsewhere

21268	Infantile (Bil.)	Birth	48 mo.	48 mo.	Down	48 mo. irregular	No	x	x		Uneventful	23 yr., OK Navy. Delayed contralateral hernia; repaired age 19 yr., elsewhere
31157	Simple (L)	16 mo.	8 mo.	24 mo.	Down	No	No	x			Uneventful	15 yr., OK Died in auto accident
26270	Simple (Bil.)	Birth	48 mo.	48 mo.	Down	No	No	x Bil.			Uneventful	Not followed
31459	Infantile (R)	6 mo.	1 mo.	7 mo.	Down	No	8 hr.†	x	x		Uneventful	1 mo., OK
31842	Simple (R)	34 mo.	2 mo.	36 mo.	Down	No	12 hr.‡	x			Uneventful	Not followed
41178	Infantile (R)	30 mo.	18 mo.	48 mo.	Down	No	7 hr.	x	x		Uneventful	16 yr., OK
45213	Simple (L)	Birth	14 mo.	14 mo.	Down	No	18 hr.‡	x			Uneventful	15 yr., OK
50095	Infantile (R)	Birth	2 mo.	2 mo.	Down	No	No	x			Uneventful	15 yr., OK
52552	Simple (R)	Birth	3½ mo.	3½ mo.	Down	No	24 hr.	x			Uneventful	14 yr., OK
87815	Simple (L)	20 mo.	4 mo.	24 mo.	Down	No	No	x Bil.			Uneventful	Not followed
	Simple (R)	22 mo.	2 mo.	24 mo.	Down	No	No					
103551	Infantile (L)	Birth	60 mo.	60 mo.	Down	60 mo.	No	x			Uneventful	3 yr., OK Operation elsewhere
118353	Infantile (L)	54 mo.	6 mo.	60 mo.	Down	6 mo.	No	x	x		Uneventful	6 yr., OK
131566	Simple (R)	Birth	24 mo.	24 mo.	Down	8 mo.	No	x			Uneventful	2 yr., OK
127851	Simple (R)	6 mo.	18 mo.	24 mo.	Down	18 mo.	2 hr.	x			Uneventful	2 yr., OK
144688	Infantile (R)	Birth	72 mo.	72 mo.	Und.	72 mo.	No	x		x	Uneventful	2 yr., OK
32229	Infantile (R)	Birth	6 wk.		Down	15 mo.	No	Deferred				17 yr., OK
31925	Infantile (L)	Birth	2 mo.		F.	2 mo.	No	Truss advised				15 yr., OK

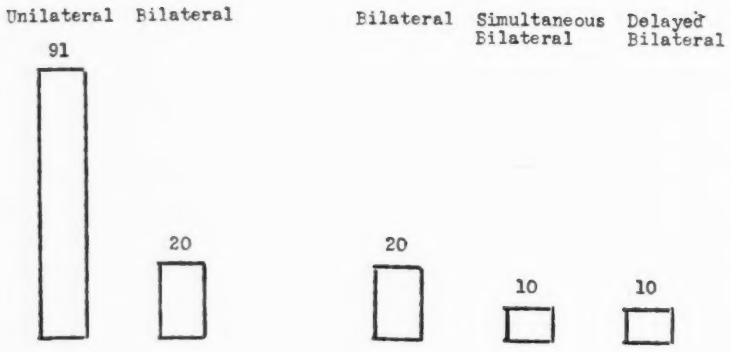
(Continued on following pages)

TABLE III—CONT'D

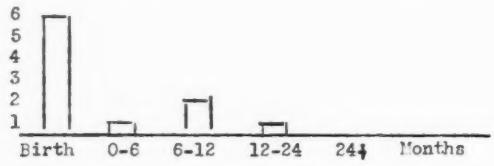
NO.	TYPE	AGE AT ONSET	DURATION	AGE AT OPER.	TESTES	TRUSS	IRREDUCIBLE INCARCERATION	OPERATION R.C.	OPERATION M.C.	OPERATION B.O.	OPERATION P.T.	P. O. COURSE	FOLLOW-UP
52865	Infantile (R) Simple (L)	2 mo.	18 mo.	20 mo.	Down	18 mo.	No	x Bil.		x R.		Uneventful	13 yr., OK
45629	Simple (R)	3 mo.	57 mo.	60 mo.	Down	45 mo.	No	x Bil.				Uneventful	1 mo., OK
	Simple (L)	4 mo.	56 mo.	60 mo.	Down	45 mo.	No						
10772	Infantile (L) Simple (R)	24 mo.	48 mo.	72 mo.	Down	48 mo.	No	x Bil.		x L.		Uneventful	18 yr., OK
151669	Infantile (R)	Birth	10 wk.	10 wk.	Down	10 wk.	No	x				Uneventful	2 yr., OK
151669	Infantile (L) C.Hyd. C. & T.V.	Birth	8 mo.	8 mo.	Down	8 mo.	No	x				Uneventful	1½ yr., OK
54786	Simple (R)	12 mo.	48 mo.	60 mo.	Down	48 mo.	No	Hernia spontaneously reduced on admission Oper. age 60 mo. elsewhere x				Uneventful	14 yr., OK
53039	Simple (R)	13 mo.	4 mo.	17 mo.	Down	1 mo.	5 hr.		x			Uneventful	14 yr., OK
54216	Simple (R)	7 wk.	3 wk.	10 wk.	Down	3 wk.	12 hr.†		x			Uneventful	14 yr., OK
87992	Infantile (R)	Birth	24 mo.	24 mo.	Down	13 mo.	5 days	x		x		Uneventful	10 yr., OK
85375	Simple (L)	48 mo.	24 mo.	72 mo.	Down	24 mo.	No	x				Uneventful	10 yr., OK
92342	Simple (R)	36 mo.	36 mo.	72 mo.	Down	36 mo.	No	x				Uneventful	9 yr., OK
24427	Infantile (R)	Birth	14 yr.	16 yr.	Down	14 yr.	No	Oper. advised at 2 yr. of age—oper. elsewhere at 16 yr. of age				Uneventful	18 yr., atrophy of testicle before operation

116680	Infantile (R) N.C.Hyd. C. & T.V.	16 mo.	24 hr.	16 mo.	Down	No	No	x	x	Uneventful	1 yr., OK
115599*	Simple (R)	29 mo.	7 mo.	36 mo.	Down	No	No	x		Uneventful	6 yr., OK
113980	Simple (R)	60 mo.	6 mo.	66 mo.	Down	No	No	x		Uneventful	1 yr., OK
109878	Simple (R)	3 mo.	9 mo.	12 mo.	Down	No	No	x		Uneventful	6 yr., OK
109306	Simple (R)	36 mo.	12 mo.	48 mo.	Down	No	No	x		Uneventful	5 yr., OK
109306	Simple (L)	60 mo.	12 mo.	72 mo.	Down	No	No	x		Uneventful	3 yr., OK
107595	Simple (R)	24 mo.	24 mo.	48 mo.	F.	No	No	x		Uneventful	7 yr., OK
107580	Infantile (R) C.Hyd. C. & T.V.	12 mo.	36 mo.	48 mo.	Down	No	No	x	x	Uneventful	3 yr., OK
97221	Infantile (Bil.) N.C.Hyd. C. & T.V.	6 wk.	1 wk.	7 wk.	Down	No	No	x	x	Uneventful	8 yr., OK Delayed contralateral hernia; repaired elsewhere
93545	Simple (R)	54 mo.	6 mo.	60 mo.	Down	No	No	x		Uneventful	6 yr., OK
90355	Infantile (L) N.C.Hyd. C. & T.V.	10 mo.	2 mo.	12 mo.	Down	No	No; Aspirated by LMD before admission	x	x	Uneventful	8 yr., OK
86945	Simple (R)	6 mo.	66 mo.	72 mo.	Down	No	No	x		Uneventful	10 yr., OK
80192	Simple (R)	24 mo.	12 mo.	36 mo.	Down	No	No	x		Uneventful	10 yr., OK
73736	Simple (Bil.)	14 mo.	8 mo.	22 mo.	Down	No	No	x		Uneventful	10 yr., OK Delayed contralateral hernia; repaired elsewhere age 10 yr.
65864	Simple (L)	47 mo.	1 mo.	48 mo.	Down	No	No	x		Uneventful	8 yr., OK
63304	Infantile (L) C.Hyd. C. & T.V.	60 mo.	1 wk.	60 mo.	Down	No	No	x		Uneventful	8 yr., OK

*Hernia not demonstrable on repeated visits.
†Spontaneously reduced under ether anesthesia.
‡Bowel required prolonged packing.



Age Apparent Onset Simultaneous Bilateral Hernia in Ten Patients



Interval Between Onset of First and Contra-Lateral Hernia in Ten Patients with Delayed Contra-Lateral Hernia

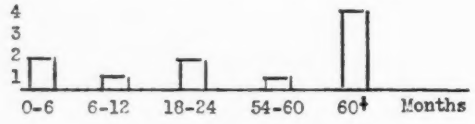


Fig. 3.—Lateralization (111 patients).

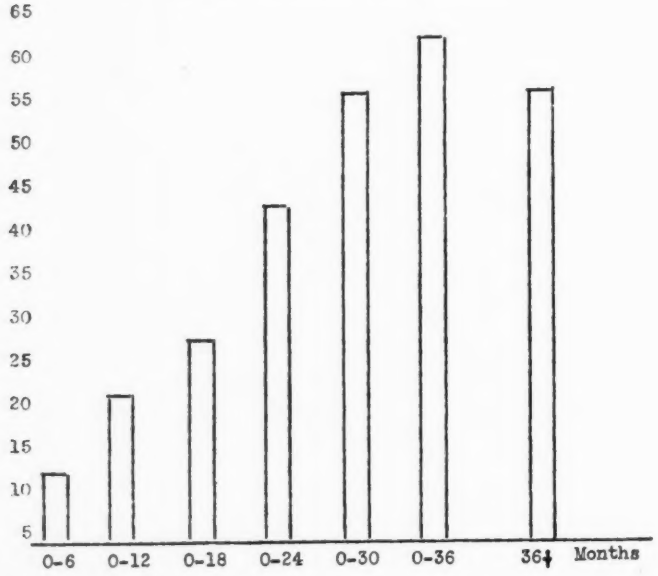


Fig. 4.—Number of herniorrhaphies done from birth to 3 years of age compared to number of herniorrhaphies done on patients 3 years of age and over. Compare with Fig. 2.

DESCRIPTION OF OPERATIVE PROCEDURES

Radical Cure.—The usual Ferguson procedure was used.

Modified Cure.—The procedure used was the Mitchell-Bankes, the external oblique usually being reapproximated.

Associated Bottle Operation.—Testicle and coverings were delivered after the external oblique was opened and redundant serosal coverings of cord and testicle were extirpated. Inversion and suture over these structures were not always performed.

Radical Cure for Infantile Hernia With or Without Hydrocele, But Without Bottle Operation.—The canal exposed and the sac simply bisected in the canal or through the upper end of the hydrocele. The proximal segment was freed up above the neck, ligated, and anchored under the arched fibers, after which the usual Ferguson procedure was carried out.

Operation for Undescended Testicle.—The infantile hernia, containing the testicle, was fully mobilized. After the sac had been freed well above the neck and bisected and ligated, the vas and vessels of the cord were freed of all adhesions at the internal ring and the vessels freed digitally extraperitoneally to the spine, and the vas freed to the vesicle. A nidus was then made in the scrotum by digital overdistention, the testicle placed in the scrotum, and the usual Ferguson procedure carried out.

Transplantation of the Cord.—Transplantation of cord was not done.

POSTOPERATIVE CARE

Dressing.—The wounds were covered with silver foil, and bulky gauze dressing was applied and sealed on with adhesive tape. No attempt was made to protect the dressing from urine.

Postoperative Medication.—Since the availability of penicillin, all patients were given 25,000 units every three hours for two days following operation. Very few received sedatives.

Postoperative Feeding and Fluid.—All were fed postnausea, usually on the evening of the day of operation. An occasional child required parenteral fluid for one day in very hot weather.

Postoperative Activity.—All children were allowed up ad lib. None were restrained. They usually pulled up on the knees within six hours postoperatively and stood in the crib by the end of the second postoperative day.

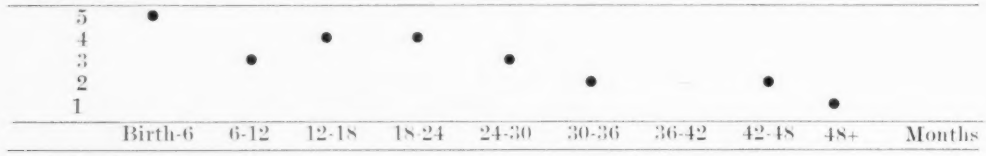
Postoperative Complications.—There were no postoperative complications. All herniorrhaphies for infantile hernia were followed by transitory swelling of the scrotum. Sutures were removed the third or fourth postoperative day and the patient was discharged without restriction of activity.

POSTOPERATIVE FOLLOW-UP

One hundred one patients were operated upon to perform 119 herniorrhaphies. All but six of these patients were followed until September, 1947. Four late contralateral operations were done elsewhere.

Duration of Follow-Up.—Follow-up studies were carried on for more than 20 years in 2 patients, 15 to 20 years in 11, 10 to 15 years in 16, 5 to 10 years in

TABLE IV. DISTRIBUTION OF TWENTY-FOUR INCARCERATED IRREDUCIBLE HERNIAS



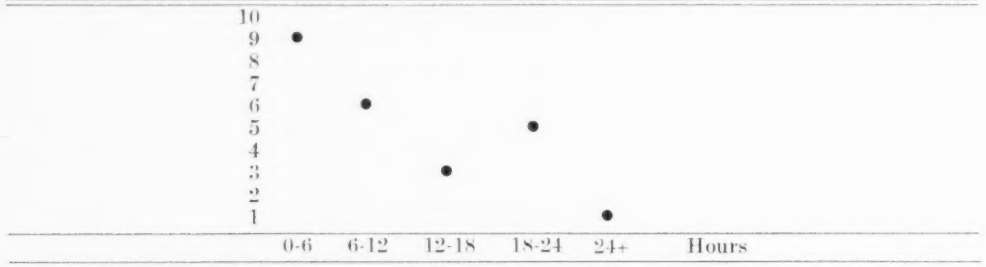
5 under 6 mo.
8 under 12 mo.
12 under 18 mo.
16 under 24 mo.
19 under 30 mo.
21 under 36 mo.
Six were wearing truss at time of incarceration.

18, 1 to 5 years in 39, and less than 1 year in 21. Follow-up could not be done on 8 hernias in 6 patients.

RESULTS OF OPERATION

Ferguson.—The Ferguson procedure was used for 107 herniorrhaphies, including 30 radical cures for infantile hernias without Bottle operation, and 4 associated operations for undescended testicle. The results were (1) no postoperative infections, (2) no postoperative hydrocele, (3) no atrophy of testicle not present before operation, (4) one death, anesthetic, (5) no recurrence.

TABLE V. DURATION OF INCARCERATION IN TWENTY-FOUR HERNIAS



8, Spontaneous reduction under anesthesia.
2, Acute appendicitis causing incarceration.
1, Gangrene, resection of tube and ovary.

Mitchell-Bankes.—The Mitchell-Bankes procedure was used for 8 herniorrhapies. The results were (1) no postoperative infections, (2) no postoperative hydrocele, (3) no atrophy of testicle not present before operation, (4) no recurrence.

INCARCERATED IRREDUCIBLE HERNIA

The distribution of incarcerated irreducible hernias in this series is charted in Table IV. In Table V the duration of the incarceration is shown. A list of the types of reduction of incarcerated irreducible hernias is given in Table VI.

TABLE VI. REDUCTION OF INCARCERATED IRREDUCIBLE HERNIA

NUMBER	REDUCTION
8	Reduced spontaneously under anesthesia
4	Bowel so badly strangulated as to require packing, but viable
1	Resection of strangulated mass required
1	Incarceration due to acutely inflammed appendix in sac
1	Incarceration due to inflammatory reaction associated with acutely inflammed appendix (ruptured) just above neck of sac

DIAGNOSIS OF INGUINAL HERNIAS

Although it is generally admitted that invagination of the scrotum is not a reliable method of establishing existence of an inguinal hernia in infancy and early childhood, the great importance of the history of a recurrent reducible mass in this region, as the only evidence of the existence of the hernia, has not been properly emphasized. It should be emphasized that failure to demonstrate a hernia, even on repeated examination, does not preclude its existence.

Any demonstrable hernia can best be examined by inspection and palpation of the inguinal region. Demonstration of a reducible mass in this region obviously establishes the diagnosis.

The association of hydrocele of the cord or tunica vaginalis and cord with infantile hernia has not been adequately emphasized. Communicating hydroceles of the cord are compressible and are always infantile hernia; noncommunicating hydroceles of the cord are uncompressible and are associated with patent vaginal process above the hydrocele in the vast majority of instances. It is difficult to understand why this important association has not received proper emphasis in previous publications.[1, 2, 3]

It follows that the scrotal approach in the surgical treatment of hydrocele of tunica vaginalis and cord, whether the hydrocele is communicating or not, is undesirable. The danger of aspiration of the communicating variety is obvious.

Sex and Age Distribution of Hernia.—The sex and age distribution of 111 patients in our series corresponds with other reported series. It will be noted that the ratio of females to males is approximately 1 to 11. The great preponderance of hernias present at birth, as compared to any other single age period, is also consistent with the experience of all others who have reported on this subject.

It will be noted that the vast majority of hernias were demonstrable before the child was 3 years of age.

TREATMENT BY YARN TRUSS

Thirty-six patients were treated by their physician with a yarn truss in the hope of obtaining a cure of the hernia, or deferring the operative repair until the patient was 5 or 6 years of age.

The extreme to which the physician went in carrying out this method of treatment, to avoid operation, is well illustrated by the two patients who were subjected to general anesthesia for irreducible incarceration before admission to Vanderbilt Hospital.

Four of the thirty-six patients, two male and two female, were apparently cured of their hernia. Two of these, who had hernias present at birth, were treated by a truss for two and fifteen months. They have been followed fifteen and seventeen years, respectively, without evidence of recurrence. One, with onset at the age of 3 months, was treated by truss for eighteen months and has been followed to the present with an apparent two-year cure. One, with onset at the age of 44 months, wore a truss seven years and has been followed to the present with an apparent twenty-year cure. The term apparent is advisedly used. The incidence of very late recurrence, especially of the infantile type hernia, apparently cured spontaneously or by truss, is well known to us.

In thirty-two patients the truss, even when carefully applied, failed to retain the hernia continuously, although the truss was worn continuously except when changed for washing the child or the truss or to replace a prolapsed hernia.

In eighteen patients, despite the truss, the hernia progressively increased in size. In fourteen patients repeated incarceration occurred. In six patients irreducible incarceration occurred while the truss was being worn.

All thirty-two of the patients, not apparently cured by the truss, came to operation. Sixteen were 4 or more years of age when the operation was finally advised. The parents of ten of the children insisted on earlier operation because of the impossible emotional strain produced upon themselves and their child by the fear of incarceration of the hernia and the filth and inefficacy of the truss.

One child wore a truss fourteen years. He developed atrophy of the testicle. Treatment by truss offers at best a very low incidence of apparent cures when one deducts the number of spontaneous apparent cures.

If used at all, the truss should have a single purpose, the prevention *at all times* of prolapse of intra-abdominal content into the hernia sac, without injury to the contents of the inguinal canal. In our experience this is a practical impossibility, and the resultant prolapse into the hernia sac carries with it the same hazard of irreducible incarceration as is encountered in the much larger group not treated by truss.

Even when a yarn truss is employed, atrophy of the associated testicle may occur.

The extraordinary emotional strain exerted on the parents by fear of incarceration, awareness of genital anomaly, and filth induced by the truss, creates an environment for the patient which often results in irreversible abnormalities in emotional stability.

For these reasons the truss has not been recommended in the therapy of inguinal hernia in infants and children during the past ten years at Vanderbilt Hospital.

THE OPERATIVE TREATMENT OF INGUINAL HERNIA IN INFANCY AND EARLY CHILDHOOD

Since 1938 it has been the policy of the staff of the Department of Surgery to recommend herniorrhaphy for inguinal hernia in infants and young children as soon as the diagnosis has been established.

In the case of the newborn infant, the recommended herniorrhaphy has been deferred until the child has regained his birth weight.

In the presence of intercurrent disease in the patient or a severe epidemic of respiratory disease, the herniorrhaphy has been deferred until the child has recovered from the illness or the epidemic terminated.

Immediate herniorrhaphy, without attempted reduction, has been recommended and carried out for all incarcerated hernia.

It must be re-emphasized that the preadmission disposition of most of the patients herein reported was not determined by the staff of the Department of Surgery at Vanderbilt, but by the patient's own physician, and that with few exceptions the age at admission to this Service is essentially the age at opera-

tion. Although the preadmission attitude toward operation resulted in a long interval between onset of the hernia and operation in many instances (Table II), 10 per cent of the herniorrhaphies were done in infants under 6 months of age, over 18 per cent were done on children in the first year of life, and over 50 per cent of all herniorrhaphies were done on children under 37 months of age (Fig. 4). This constitutes a sufficient number in each age group to draw definite conclusions as to the safety and efficacy of herniorrhaphy.

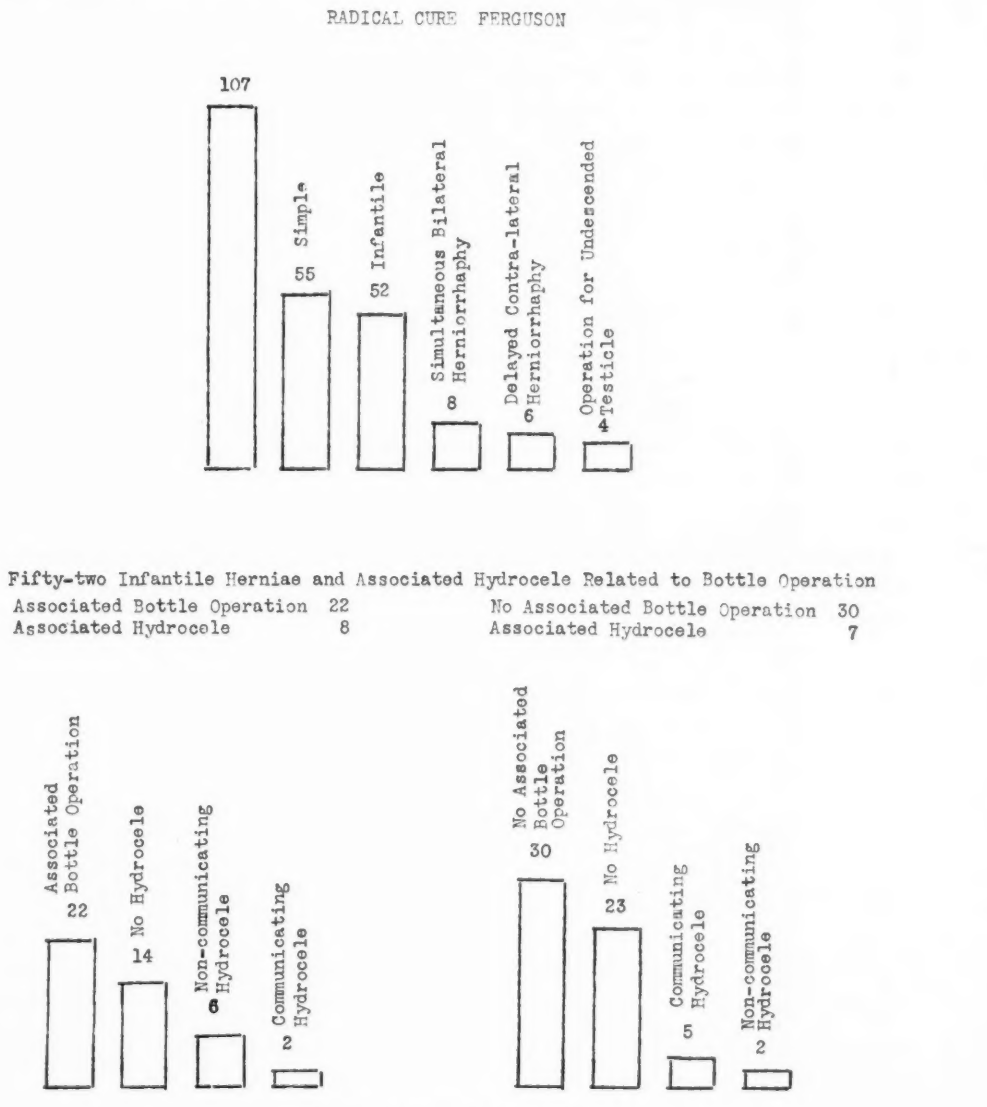


Fig. 5.—Type of procedure carried out.

There were 115 herniorrhaphies carried out without postoperative infection, residual hydrocele, testicular atrophy, or recurrence. There was one anesthetic death, thought to be due to ventricular fibrillation (Table III).

It will be noted from Fig. 5 that 107 of the herniorrhaphies were radical cures by the Ferguson method. Fifty-two of these were done for infantile

hernia. Although an associated Bottle operation was done on twenty-two of these patients, six with noncommunicating and two with communicating hydrocele, no associated procedure was carried out on the scrotal contents in thirty of the fifty-two patients with infantile hernias, five of whom had communicating hydrocele and two of whom had noncommunicating hydrocele associated. It follows that in the cure of infantile hernia, with or without associated hydrocele, whether communicating or not, it is unnecessary and undesirable to perform an associated Bottle or similar type operation on the coverings of the scrotal cord and testicle. The hernia sac should be simply bisected in the inguinal canal or through the upper end of the hydrocele, after which the upper portion of the sac is freed and ligated above the neck. The lower portion of the sac should be disregarded.

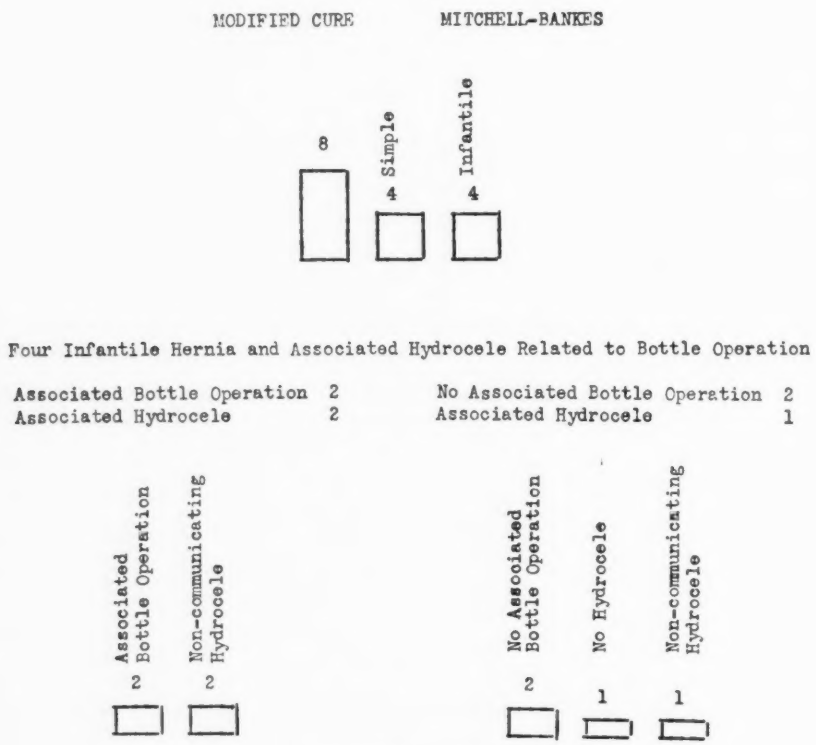


Fig. 6.—Type procedure carried out.

It is further noted, from Fig. 5, that there were eight simultaneous bilateral herniorrhaphies performed, as compared to six delayed contralateral herniorrhaphies. Although we are convinced that contamination of the properly closed wound by urine, etc., can only rarely result in infection, we are well aware of the hazard of contamination during the process of operation. Although there were no instances of infection in our series (Table III), in a decision involving bilateral simultaneous herniorrhaphy the danger of accidental contamination in a young child or infant must be seriously weighed against the advantages, principally economic, to be gained by a simultaneous bilateral herniorrhaphy. Where

practical, we advised an interval of four to six weeks between herniorrhaphies when bilateral hernia coexisted in this series.

There were eight herniorrhaphies carried out by the Mitchell-Bankes method (Fig. 6). Four of the hernias repaired by this method were infantile; in two of which an associated Bottle operation was performed, and in the remaining two no associated procedure was carried out on the coverings of the scrotal cord or testicle. All the patients were cured and there was no postoperative residual hydrocele or testicular atrophy.

The simplicity of this procedure makes it ideal for the treatment of simple hernia, especially simultaneously present bilateral hernia. When dealing with an infantile hernia with a residual space in the scrotum, we have generally reconstructed the inguinal region by the Ferguson method, so that if the ligature of the neck did not hold, there would not be a complete prolapse into the scrotum. The few additional sutures to carry out this procedure in an infant or young child add very little time and trauma to the operation. It is an indispensable step in the associated operation for undescended testicle, four of which were encountered in the canal or abdomen in this series and were brought well down into the scrotum by the method described.

THE TREATMENT OF INCARCERATED HERNIA

Since it is impossible to predict the degree of ischemia on the basis of the time factor alone, and since incarceration is frequently brought about by an inflammatory reaction above or within the sac, we are unalterably opposed to the preliminary packing period and attempts at reduction of incarcerated hernia as recommended by Ladd and Gross,[1] Thorndike and Ferguson,[3] and others.

We have always regarded incarcerated hernias as extreme emergencies. For practical purposes they are all strangulated.

We have, therefore, carried out immediate herniorrhaphy under ether anesthesia without preliminary attempts at reduction when an inguinal hernia has become acutely painful, tender, or firm, whether or not associated with signs or symptoms of intestinal obstruction.

In our series there were twenty-four incarcerated hernias. It is noteworthy that 87.5 per cent of all incarcerated hernias in our series occurred in children under 3 years of age and that 33⅓ per cent of all incarcerated hernias occurred in children under 13 months of age.

Some of these patients had been subjected to prolonged and forceful attempts at reduction prior to admission to Vanderbilt University Hospital. There was no attempted reduction after admission. All were operated upon as soon as the child could be prepared and the operating room made ready. All operations were done under ether anesthesia. Eight reduced spontaneously under anesthesia. Because of the prolonged duration of the incarceration, one of these had an associated exploratory laparotomy. In four the bowel was badly strangulated and required prolonged packing to establish its viability. In one, resection of the strangulated mass was required. In one the incarceration was due to an inflammed appendix in the sac, and in one other the incarceration

was due to an acutely inflammed appendix just above the neck of the sac, and after repair of the hernia the appendix was removed through a new incision.

Although the inguinal structures were edematous, all structures could be identified, and a satisfactory repair was carried out in each instance. There were no postoperative infections and there have been no recurrences.

SUMMARY

1. The truss should not be employed in the treatment of inguinal hernia in infancy and early childhood. The cures are rare, the danger of the hernia is not diminished, the fear of the hernia by the parent and the inefficacy and filth of the truss result in an environment that produces profound emotional disturbances in both the parents and the child.

2. Compressible hydroceles of the cord or cord and tunica vaginalis are communicating hydroceles and are always infantile hernia.

3. Noncompressible hydroceles of the cord or cord and tunica vaginalis are noncommunicating hydroceles and in 80 per cent of our cases were accompanied by a definite hernia of the upper portion of the vaginal process.

4. Hernia in infants and young children should be treated by operation. Operation should not be deferred because of the age of the patient.

5. It is unnecessary and undesirable to carry out associated Bottle or other operations on the coverings of the scrotal cord and testicle when doing a herniorrhaphy for infantile hernia with or without associated hydrocele.

6. Incarcerated hernia should be operated upon immediately without attempts at reduction.

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